MA

military automation

SYSTEMS AND COMPONENTS FOR MILITARY ELECTRONICS · INSTRUMENTATION · AUTOMATION

MAY—JUNE 1957

CHARACTRON . . .

shaped-beam tube is versatile air-surveillance display tool with many uses in data processing, computer monitoring and rapid communications.

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ARMY AUTOMATION . . .

developments are pictorially reviewed.

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ALSO—

CYTAC, Unified R & D, Missile-borne Tape Recorder, Printed Circuitry, Digital Techniques, Analog Computers, and Redstone Particle Accelerator.

INSTRUMENTS PUBLISHING COMPANY • PITTSBURGH 12, PA.

In This Issue

We introduce new techniques applied in air-control display by the "Charactron" shaped beam principle; significant Army advances in automation and miniaturization are pictorally presented; and we report on the Armed Forces Communications and Electronics Association annual meeting in Washington. We are also proud to reveal that leading Armed Forces technical liaison personnel met and cordially welcomed the staff of *Military Automation* magazine at a reception, as reported on page 128.

In this issue we also begin a series of tutorial articles on servos. This series will provide the same treatment for an important family of control devices that we are accomplishing in "Digital Techniques" and "Printed Circuitry." Our "Analog Computer" series is continued in this issue with an analysis of the economic factors related to analog computer applications.

Featurettes cover cooperation between the research agencies of the Services ("Unified R & D"), spin stabilization of rockets by solid propellants, temperature monitoring by a simple tape-on resistor, a new Loran-type development called CYTAC, the new Van de Graaff accelerator at Army's Redstone Research and Development Center, the use of missile-borne tape recording in missile testing, and some test details of the first specification for power transistors authorized by the Signal Corps.

In this issue we follow a reader's suggestion that we sandwich short articles between the principal feature articles so that those who wish to file clippings will not need to sacrifice a major article.

MA "Subscriptions"

Military Automation is mailed without charge to qualified applicants who follow the instructions provided on page 122, at their business addresses. No mailings outside the United States, except to military post office numbers, will be made. Back copies cannot be furnished, and articles will not be reprinted except in orders for 100 or more, for which the actual cost of reprinting will be charged.

Mailing may be made to a military billet address in lieu of a name, if the application form is signed by or at the direction of the commanding officer of the activity. A description of the billet duties must be given to assue circulation auditors that the recipient is a qualified addressee. Application forms, properly executed and signed, are equivalent to money payments for subscription type magazines, and your care in filling out the questions asked is respectfully requested.

MA

VOL. 1, NO. 3

MAY-JUNE
1957

MA *Military Automation*

Published bimonthly by Instruments Publishing Company, Inc., 845 Ridge Ave., Pittsburgh 12, Pa. Printed at 1600 N. Main St., Pontiac, Ill. Acceptance as Controlled Circulation Publication at Pontiac, Illinois, pending.

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(Commander U.S. Naval Reserve)

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St. Louis 1—Steve Wright, 706 Chestnut St. Chestnut 1-1965.

Subscriptions

Circulated without charge to qualified engineers and executives in organizations which develop, manufacture, purchase, install, or maintain electronic and control equipment and systems for military applications; officers and engineers in the Armed Forces responsible for design specification, test, or maintenance of such equipment; scientists and engineers in development and research for the Armed Forces. Qualified individuals in the United States may request this publication by providing the following information on their company letterhead: Your name and title; your job function as related to your company's products or services for the Military; your company's name, address, and nature of business as related to military end products or applications. Available to others in the U. S., by subscription, at the rate of $10 per year.

In Preparation

Our July-August issue will appropriately focus attention on the WESCON SHOW by featuring a special section of new products which will be unveiled by manufacturers at that convention.

Our next issue also will feature material on Radiometric Inertial Navigation, a survey of Air Traffic Display Systems, Automation applied to the Duplication and Filing of Engineering Drawings by the Armed Services, and a guest editorial by an Army scientist on Research and Development Programs. We shall also continue development of Servomechanisms, Large Digital Computer applications, and Printed Circuit Technique articles.

Other articles in preparation for future issues concern firecontrol developments, scatter communications, UHF measurements, wind tunnel instrumentation, travelling-wave, backward-wave, and Klystron tube applications; analog and digital computers in military systems research, automatic assembly of electronic equipment, radiac measurements, electronic systems testing, and automation in the Reserve Fleet. In response to reader requests we are also working on an explanation of the Military Specifications and Standardization Programs.

Definitions

SHORAN *Shortrange Navigation* for precision position finding. Signals from an omnidirectional airborne radar trigger two ground-based transponder beacons, thus providing a fix based on two accurate ranges.

ICBM *Intercontinental Ballistic Missile*

IRBM *Intermediate Range Ballistic Missile*—approximately 1500-mile maximum range.

Ballistic Missile. Any missile guided especially in the upward part of its trajectory but becoming a free-falling body in the latter stage of its flight through the atmosphere.

DME *Distance-measuring equipment*

Command-guided Missile. A missile guided by a system requiring one radar to watch the target, the other to track the missile. A computer combines the data from each radar to give flight directions to the missile.

TAC *Tactical Air Command,* U. S. Air Force.

TacAN *Tactical Air Navigation*

Beam-riding Missile. A missile guided by a system in which the missile rides along a beam, usually a radar signal, to its target. Control is usually exercised over the missile while in flight by motion of the beam while it is also tracking the target.

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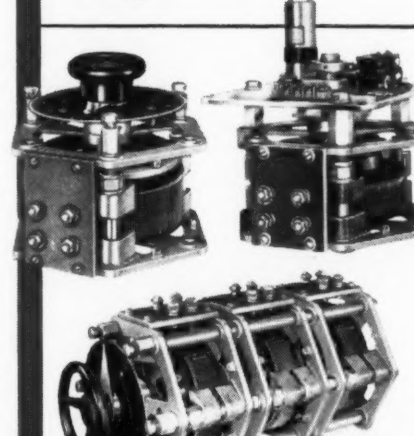
HL SERIES

INPUT		OUTPUT				MANUALLY-OPERATED MODELS				MOTOR-DRIVEN MODELS				
VOLTS	FREQUENCY CYCLES PER SECOND	VOLTS	MAXIMUM AMPERES	MAXIMUM KVA	TYPE OF CONSTRUCTION	TYPE	METHOD OF TURNING	APPROX. WEIGHT (POUNDS) NET	SHIPPING	TYPE	STANDARD MOTOR-DRIVES	SPEED OF TRAVEL IN SECONDS	APPROX. WEIGHT (POUNDS) NET	SHIPPING
SINGLE PHASE														
28	400/800	0–28	2.0	.056	Open	3HS02UK	Knob	0.5	0.9					
28	400/800	0–28	4.0	.112	Open	3HS04UK	Knob	0.8	1.2					
120	400/800	0–120 or 0–140	1.0	.14	Open	1HS01UK	Knob	0.9	1.3					
120	400/800	0–28	2.6	.073	Open	1RHS03UK	Knob	0.6	1.0					
120	400/800	0–120 or 0–140	3.0	.42	Open Square Frame	1HMS03UK	Knob	2.4	2.8	DM1HMS03U	28 Volt D-C	60	4.5	5.1
										AM1HMS03U	120 Volt A-C, 400 Cycles	60	4.5	5.1
120	400/800	0–120 or 0–140	7.5	1.0	Open Square Frame	1HMS07UK	Knob	3.4	3.8	DM1HMS07U	28 Volt D-C	60	5.5	6.1
										AM1HMS07U	120 Volt A-C, 400 Cycles	60	5.5	6.1
120	400/800	0–120 or 0–140	15.0	2.1	Open	1HL15UK	Knob	11.4	14.0	DM1HL15U	28 Volt D-C	60	13.2	16.2
										AM1HL15U	120 Volt A-C, 400 Cycles	60	13.2	16.2
240	400/800	0–240 or 0–280	3.0	.84	Open Square Frame	2HMS03UK	Knob	3.4	3.8	DM2HMS03U	28 Volt D-C	60	5.5	6.1
										AM2HMS03U	120 Volt A-C, 400 Cycles	60	5.5	6.1
240	400/800	0–240 or 0–280	9.0	2.5	Open	2HL09UK	Knob	12.8	15.4	DM2HL09U	28 Volt D-C	60	14.6	17.6
										AM2HL09U	120 Volt A-C, 400 Cycles	60	14.6	17.6
THREE PHASE														
240	400/800	0–240 or 0–280	3.0	1.5	Open	2HMS03UK-3Y	Knob	7.6	8.5	DM2HMS03U-3Y	28 Volt D-C	60	9.3	10.5
										AM2HMS03U-3Y	120 Volt A-C, 400 Cycles	60	9.3	10.5
240	400/800	0–240 or 0–280	7.5	3.6	Open	2HMS07UK-3Y	Knob	10.6	11.6	DM2HMS07U-3Y	28 Volt D-C	60	12.3	13.6
										AM2HMS07U-3Y	120 Volt A-C, 400 Cycles	60	12.3	13.6
240	400/800	0–240 or 0–280	15.0	7.3	Open	2HL15UK-3Y	Knob	34.5	41.0	DM2HL15U-3Y	28 Volt D-C	60	38.0	45.0
										AM2HL15U-3Y	120 Volt A-C, 400 Cycles	60	38.0	45.0
480	400/800	0–480 or 0–560	3.0	2.9	Open	4HMS03UK-3Y	Knob	10.6	11.6	DM4HMS03U-3Y	28 Volt D-C	60	12.3	13.6
										AM4HMS03U-3Y	120 Volt A-C, 400 Cycles	60	12.3	13.6
480	400/800	0–480 or 0–560	9.0	8.7	Open	4HL09UK-3Y	Knob	39.0	45.5	DM4HL09U-3Y	28 Volt D-C	60	42.5	49.5
										AM4HL09U-3Y	120 Volt A-C, 400 Cycles	60	42.5	49.5

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MA

We heartily thank each of the following who took time to congratulate us on our first issue.

Editor, MA:

I have just read your Vol. 1 Number 1 of *MILITARY AUTOMATION*. From the statement of the mission of this publication, as expressed by Commander C. O. Morrison, I feel that *MILITARY AUTOMATION* will serve as a valuable source of information for engineers connected with military electronics. May I request that my name be placed on the mailing list to receive *MILITARY AUTOMATION*.

Harold Rosenblum
Head, Flight Trainer Branch
U S Naval Training Device Center.

Editor, MA:

I would appreciate being placed on the mailing list of *MILITARY AUTOMATION*. I am particularly interested and pleased with the articles on Modern Digital Techniques and the Analog Computer.

Pierre M. Honnell,
Professor of Electrical Engineering
Washington University,

Editor, MA:

Congratulations on your first issue of *MILITARY AUTOMATION*. Though the galleys you showed Ken Mabuchi and me looked good, the final article really came across with a bang. With best wishes for the success of your new venture.

Henry Lazarr,
Smith, Winters, Mabuchi, Inc.

The foregoing letters of congratulation arrived too late for inclusion in our second issue. Thanks very much for your kind wishes. Your requests have been relayed to our circulation department.

Editor, MA:

I have been actively engaged in electronics since 1937 and have been in my present position as electronics instructor in North American Aviation's industrial training school for nine years. I have the privilege of being on your mailing list for *MILITARY AUTOMATION* and I would like to congratulate you on the modern, up-to-the-minute, useful, informative publication you are editing. The information contained in the first issue is extremely valuable to me in my duties. Please correct my address as given below to preclude any possibility of misdirecting future copies.

Thank you very much for including me in your files.

Charles G. King
Electronics Instructor
North American Aviation, Inc.

Thanks very much for the encouragement. Keep us informed of which articles you find of most value

in your classes. Also, we will welcome your suggestions on other topics you would like to have treated. We have our ideas, as set forth under heading "In Preparation," but they are constantly being modified to be in line with the greatest need for information, as suggested by our readers.

Editor, MA:

I was favorably impressed by both the appearance and content of *MILITARY AUTOMATION*. I concur with your comments on the need for this type of publication and believe that you are accomplishing your mission as stated in your editorial. From the technical reproduction standpoint it is a fine job. The type is clear and very readable and the illustrations are good. The articles are well written and the pictures appropriate. I am certain that this new publication will be well received.

I do not care for the 11-inch page width instead of the usual 8 inch. Its larger size makes it a bit awkward to handle. The excess width necessitates folding the magazine for mailing, resulting in a more or less permanent crease down the center of the page. This detracts from the readability of the center column. The magazine must again be folded in order to route it, since it will not fit into the desk incoming or outgoing basket. Also it will not fit into the ordinary filing cabinet drawer or bookshelf without folding or overhang, creating a storage problem. One additional item on format—Some of the advertising at first glance is not readily distinguishable from the articles.

I liked the combination of long articles with the shorter ones interspersed among them. The basic theory articles are very good. It might be a good idea to save the plates and reprint the series in booklet form at some future date. The articles on "Dynamic Aero-Ballistics" I thought was a bit too detailed for the type of publication you are trying to achieve. I realize that it is difficult to get a spread of good items for the first issue, but I thought that too many of them revolved around aviation, particularly Naval Aviation. I counted two major articles, five minor, and the "Bio-Bit."

Most of your "Regular Features" are very good. I would, however, suggest the deletion of one and the possible addition of another. "*MA* Contracts" is good only if it is timely. This is difficult to accomplish in a bi-monthly. The additional feature that might be given some consideration is a digest of articles pertinent to military automation appearing in other periodicals. This might also be expanded to include book reviews.

Best wishes for success in your new endeavor.

Arthur Goldsmith, CDR, USNR
District Reserve Electronics
Program Officer, 12th ND.

Thanks very much for your good and carefully considered comments. Your many kind words are appreciated greatly. Your reaction on the king-size width has many points from which we can profit, such as the wrapping for mailing which probably can be improved. Subsequent handling problems are beyond us, and are one of the penalties which we must pay. The reason for the new format is, of course, the same as for the larger, longer car models —namely, the opportunity to make a more striking visual presentation of material!

The optimum technical level may always be difficult to gage. While you found "Dynamic Aeroballistics" too detailed, such details are desired by many readers who are in some type of dynamic testing laboratory. A good balance over a period of months between the various services, and branches within services, is our present goal. We concur in your appraisal of the "Contracts," and in your suggestion that articles and books of interest be abstracted for our readers. Articles from foreign technical sources, particularly the excellent *British Communications and Electronics*, should be of interest to military readers. We appreciate your ideas and your encouragement. Thanks a lot.

Editor, MA:

Have read your new publication carefully from cover to cover and found it very interesting—far superior to what I had anticipated. I am sure that if your quality can be maintained you will have a much desired magazine. The articles were very well written and the subjects were well chosen to be of interest to all electronics people. One of the things I have noticed concerning publications that are advertiser sponsored is that many publisher's first volumes have a good balance between articles and advertising but soon afterwards the over-all quality degenerates towards all advertising. I hope this will not happen to *MILITARY AUTOMATION*. Am sure as time goes on good material will become increasingly difficult to find, but then it will be up to you to dig deeper. Your goals are well taken and important.

Am looking forward to receiving future copies of *MILITARY AUTOMATION*.

Richard D. Cooper
Philco TechRep, METU-9

Thanks for the sobering thoughts, Dick. I am going to post your letter on my office bulkhead where I can see it frequently. The preparation of instructive articles does take much more time, but the number of subjects to be treated in this fashion now seems inexhaustible. Fortunately, we have many capable writers either in the armed services or identified with suppliers of military equipment who will help us. The number of new developments or extensions of older principles into new applications is continually growing, and our goals stated in our first issue will probably be there to shoot at for some time.

Editor, MA:

The first issue of *MILITARY AUTOMATION* looked very good, and you are all to be congratulated. At least Instruments Publishing Company now is the only one publishing three magazines with three different sizes—standard, square, and tabloid. You must have a lot of fun trying to stack them on your desk.

George H. West
Consolidated Electrodynamics Corp.

You name it; we have it!

Editor, MA:

Can you advise who manufactures apparatus to perform a static load test as per Section 4.3.2.3.1. of Military Specification MIL-P-116B?

M. B. Kanter
Andrew Technical Supply
1543 W. Morse Ave.
Chicago 26, Ill.

Sorry, we do not have this information, but hope that some of our readers will pass you the word.

The AFCEA Convention

Introduced by the convention slogan: "Marconi to Mars," papers presented by speakers at the technical sessions of the Armed Forces Communications and Electronics Association National Convention (May 20-22) at the Sheraton-Park Hotel in Washington, D. C., covered problems in missile testing, Vanguard telemetering, data transmission and processing, air traffic control and conservation of the radio-frequency spectrum through single-sideband, multiplexing, and narrow-band transmission techniques. A symposium on scatter propagation was moderated by RADM Joseph N. Wenger, JCS.

RADM Frederick R. Furth, USN-Ret. was elected President of the Association, succeeding Col. Percy G. Black, USA-Ret., Assistant Vice President, Automatic Electric Company. Admiral Furth was awarded the Legion of Merit for his contributions to Naval Electronics during World War II. He later served as Director, Naval Research Laboratory, and as Chief of Naval Research. Placed on the retired list at his own request

RADM F. R. Furth, USN-Ret., Elected President of Armed Forces Communications and Electronics Association for 1957.

1 Jan. 1956, he joined the staff of the International Telephone Telegraph Co., first with Farnsworth Electronics Co., and on 1 March 1957 as Deputy Director of Research and Development, I.T.&T. Co., New York.

Admiral Furth, in an interview with CDR Morrison of *MA*, spoke of the recent growth of the Association and stated that plans were being made for further expansion of both group and individual memberships. He stressed the purpose of the Association as to bring industry and the military together on a partnership basis for a solution of the mutual problems of national defense.

Other officers elected are: Maj. Gen Alvin L. Pachynski, USAF, Director of Communications, First Vice President; Maj. Gen James D. O'Connell, USA, Chief Signal Officer, Second Vice-President; RAdm Henry C. Bruton, USN, Director, Naval Communications, Third Vice-President; Col. Joseph E. Heinrich, USAR, Staff Supervisor, Long Lines Department, A.T.& T. Co., Fourth Vice-President; Col. John E. R. Howland, USA-Ret., General Sales Manager, Dage Television Div., Thompson Products, Inc., Fifth Vice-President.

Among the exhibits, scatter propagation equipment, new facsimile techniques and air-traffic control and display systems were of particular interest. Single-sideband systems vied with a synchronous-detection double-sideband method of establishing reliability in airborne and land-based communications. For the visitor who wished to thoroughly explore the exhibits, the relatively uncrowded show was a relief from the congestion of larger conventions.

Dit-Mco Tester used by Westinghouse

In our March-April issue, a cable-harness checker (reproduced below) was shown in the feature article "Component-Test Automation". Readers have asked about the identity of this machine. It is a DIT-MCO Model 200 circuit analyzer, manufactured by Dit-Mco, Inc., Electronics Div., 911 Broadway, Kansas City, Mo.

DIT-MCO Model 200 CIRCUIT ANALYZER finds cable harness faults at Westinghouse Air Arm.

A novel method is used on the check sheet shown on the machine being demonstrated. Any cable fault will light two lamps on the checker—one lamp in the row across the top of the chart and one along the left edge of the chart. This indicates a single square on the chart, at the intersection of the vertical file and the horizontal row signalled by the lights. A quick check pencilled in this square is sufficient to indicate the nature of the fault to the repairman, who can make the repair and return the cable for retest with a minimum of lost time. Multiplier sections can extend the capacity of the Model 200 from 200 circuits up to 1600 circuits.

For more information circle **206** on inquiry card.

MA

Military TLO's Meet MA Editors

A reception at the Sheraton Park Hotel, Washington, D. C. May 23, provided an opportunity for technical liaison officers from Armed Forces headquarters to make or renew their acquaintance with Commander Claude O. Morrison, Editor, and Major James Eden-Kilgour, USAF-Ret., Associate editor of *Military Automation.* Guests were entertained at noon luncheon by Mr. Richard Rimbach, publisher. Brief talks on aims and plans for the new magazine were made by Mr. Milton Aronson, Editorial Director, and Commander Morrison.

MILITARY AUTOMATION LUNCHEON at Sheraton Park Hotel

The Guests were reminded that technical publications are of two basic types—newsy versus educational. It was brought out that most available publications, particularly the newer ones, are primarily news reporters, but that the much tougher job of basic education in modern technologies was and is in great need—and that this is the important mission of *Military Automation.* The editorial approach and philosophy of MA was described in detail to the luncheon guests. First and second issue copies were examined by the guests and many expressed their belief that MA will prove a unique and valuable instrument for intraservice and for service-to-industry instruction and liaison.

Guests included: Captain E. T. Calahan, US Coast Guard; Colonel Maurice F. Casey, Information Service, Secretary of Air Force; Major John S. Chesebro, Office of Information, US Army; Mr. E. Chewning, Office, Secretary of Defense; Major John B. Finigan, Office of Information, Army Chief of Staff; LCDR Herbert H. Gimpel, USN, Office of Naval Information; Colonel J. G. Kelsey, Office of Chief Signal Officer; Lt. Col. Gerald P. Lerner, Office of Chief Signal Officer; Dr. O. W. Margrave, Navy Training Publications Center; Mr. Benton H. Schaub, Office, Secretary of Defense, and Dr. Harold A. Wooster, Air Force Office of Scientific Research.

Other guests who met the editors at cocktails in the afternoon were: Mr. Oliver B. Bragg, Bureau of Ships; Mr. Charles Garland, Office, Chief of Naval Operations; Mr. Harry S. Cook, HQ U.S. Air Force; Mr. J. J. Hession, Bureau of Naval Personnel; Mr. John M. Hetrick, Air Force Office of Scientific Research, Captain and Mrs. M. E. Jansson, Naval Research Laboratory; Dr. Karl F. Oerlein, Armed Forces Special Weapons Project; Colonel R. P. Rosengren, Office of the Chief of Engineers, DA; Mr. James Sunderman and Lieutenant James Perkins, Air Force Information Service; Colonel Daniel Parker, Office of the Chief of Information, DA; Professor Benjamin H. Williams, Industrial College of the Armed Forces; and Mr. Preble Stover, CAA, Dept. of Commerce.

Major Eden-Kilgour, USAF-Ret. Appointed Associate Editor MA

Major James Eden-Kilgour, USAF Retired, has the distinction of having been recalled to active duty four times since World War II. His experience has included extensive operations in administration of Air Force air-control centers, Air Force and Army communications, Airborne Electronics and aircraft control and warning groups overseas. He was responsible for the preparation of radio and radar service procedure publications for the Air Force, including technical manual preparation for certain equipments. This experience, and acquaintance with his many service friends particularly fit him for his new editorial duties.

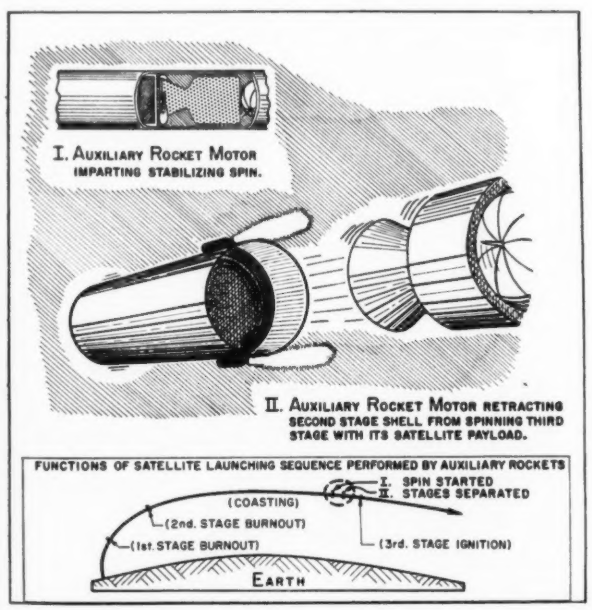
The Wescon Show

A RICH fare of 225 technical papers in 48 sessions will be offered conventioneers at the San Francisco Cow Palace from August 20 to 23. These papers were selected from an unprecedented 552 abstracts offered, according to Mr. Dean A. Watkins, chairman of the Technical Program Committee. Simultaneous sessions in six 400-person capacity meeting rooms will ensure easy accessibility between sessions and the exhibits. It may also provide standing room only for latecomers attracted to subjects of greatest interest. Only one special night session, at the Fairmont Hotel on "Controlled Fusion Research" will be held away from the Cow Palace.

Military equipment and applications are expected to predominate at the WESCON as at the National IRE show in New York. Military Automation magazine will be represented in the Instruments Publishing Co. booth, No. 612. More details on the show will be given in our next issue.

Spin Stabilized

SOLID-PROPELLANT rockets will spin and separate the third stage of the Project VANGUARD satellite launching vehicle. The spinning step is carried out while the third stage assembly is still attached to the second-stage rocket shell.



Drawing courtesy Atlantic Research Corp.

When the third-stage rocket is whirling at full speed (approximately 200 rpm), the retro motor auxiliary rockets will fire. Their firing will retard the flight of the second-stage shell, causing the third stage to move off its bed. When free of the second-stage shell, the spin-stabilized third-stage rocket motor ignites to begin the final power flight of the launching sequence.

For more information circle **207** on inquiry card.

MA

The purpose of these short biographical sketches is to provide our readers with an insight into the lives of some of the military and scientific leaders now guiding the development of automation in the different branches of the U. S. Armed Forces.

The growth of the importance of electronics in the Air Force can be traced by following the career of Colonel Gordon T. Gould, Jr., subject of this issue's Bio-Bit and Director of the Communications and Electronics Directorate of USAF's chief research agency, the Air Research and Development Command.

COLONEL GORDON T. GOULD, JR.

When Colonel Gould graduated from the U. S. Military Academy in 1941 as a distinguished cadet, radar and other electronic fields were in their commercial and military infancy. It was at this time that Gould had his first assignment in the radar field.

This new subject, radar, became new knowledge to Colonel Gould as he completed the Engineering 270 course at Harvard in 1941. Although slated to attend the advanced radar course at M.I.T., the Japanese attack on Pearl Harbor postponed this study.

The military conflict developed an immediate need in the U. S. for trained radar crews. To achieve this, the Colonel was sent to the Third Interceptor Command at Drew Field, Tampa, Florida, to establish a maintenance school for the SCR 268 and 270 radar sets. Although he had never seen a radar set, he learned as he taught the first group of students, and later wrote a textbook for the course. This school evolved into the huge Aircraft Warning Unit Training Center.

This first assignment was typical of succeeding jobs —matters of plunging into a new field and applying new electronic equipment to actual operating conditions. Subsequent assignments included planning and establishing radar installations along the Gulf Coast, improving air communications using VHF, establishing an air defense system to protect the B-29 bases in China, instituting a large radio broadcasting system also in China, planning and implementing communication and navigation facilities to airlift Chinese Nationalist troops into an area that had been occupied by the Japanese and performing the duties of the Chief of Staff of the Headquarters of the Airways and Air Communications Service, Washington, D. C. The latter job he performed so efficiently that he was presented with the Commendation Ribbon. For his work with the radio and radar systems in China, Colonel Gould received the coveted Legion of Merit and a comparable medal from the Chinese government.

In 1948, Colonel Gould, already a veteran in the field of communications and electronics, started graduate work at the Massachusetts Institute of Technology. Although he had been away from formal education for some seven years, the Colonel met the high academic requirements of M.I.T. and received his masters degree in 1950 in electrical engineering.

Following this he was assigned to ARDC's Wright Air Development Center in the Electronic Sub-division. Here he was responsible for the development of drone guidance and instrumentation equipment, as well as associated ground support equipment for the atomic tests at Eniwetok.

His next assignment kept him at WADC as Assistant Chief, and later Chief, of the Armament Laboratory. His contributions here resulted in an expanding reputation in electronic research and development.

In the summer of 1953 he attended the Air War College and, upon graduation in 1954, became Chief of the Communications and Electronics Division of Headquarters ARDC.

In this position Colonel Gould guides and directs the entire Air Force program in electronic research and development. He exercises direct supervision over development of electronic systems as they apply to radar, communication, and navigation devices. In addition, he provides guidance for electronic systems as applied to air weapon systems and other Air Force fields. His work includes supervision of development of new and improved components for electronic systems.

A native of Mobile, Alabama, Colonel Gould is married to the former Lois Sameth of Glen Ridge, New Jersey. The Goulds have two children, Gordon T. Gould, III, age 14, and Beverly L., age 7. The Colonel

and family now live in Annapolis, Maryland, where they find relaxation in boating and water-skiing.

However, much of his spare time is occupied in a typical "busman's holiday" manner. Never able to say no, the Colonel finds himself solving the radio problems of his many friends by helping repair their radio, television, and record sets.

Mrs. Gould, typical of most officers' wives, is very active in military affairs for the ladies. She is now president of the 500-member ARDC Officers Wives Club.

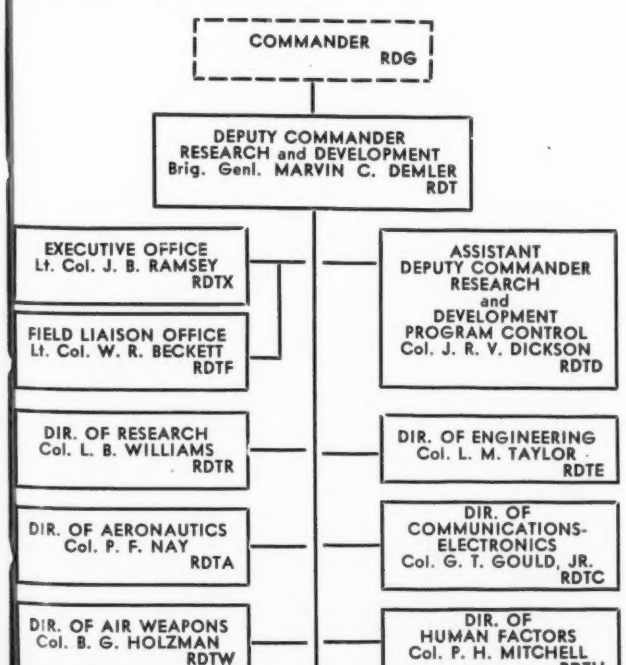
Colonel Gould is a member of the M. I. T. chapter of the Sigma Xi Society and a Senior Member of the Institute of Radio Engineers. His professional group memberships include being a member of the Board of Directors of the East Coast Conference of Aeronautical and Navigational Electronics and Vice-Chairman of the Administrative Committee of Military Electronics.

From teaching the use of the first radar sets to supervising developments relating to the complex SAGE system of today, comprises 16 short but eventful years in both the life of Colonel Gordon T. Gould, Jr., and the evolution of military electronics.

REORGANIZATION

Reorganization of the Office of the Deputy Commander for Research and Development at Headquarters, Air Research and Development Command (ARDC) was effected on April 15, 1957. This gives the Deputy Commander closer control of the activities for which he is responsible by creating a direct line of communication between new Directorates and the Deputy Commander. The present organization of the Directorate of Research and the Directorate of Engineering will not be affected.

The organization chart illustrates Col. Gould's position in the new arrangement.



Excerpts from important manufacturers' literature

Optical Glide Path Indicator

As you complete your final approach you see a ball of light reflected from a mirror on the port side of the flight deck. Your job is to adjust your angle of approach so that the ball of light appears in the center of the mirror. This assures you of a correct glide path.

Glide path is perfect when the ball of light is dead center on the mirror. The absence of flashing red "Wave-off" lights on either side of the mirror assures you that the ship and its crew are ready. The mirror is automatically stabilized to compensate for the carrier's pitch and roll.

As you level off and "flare out" the ball of light drops to the bottom of the mirror. In less than a second the tail hook will engage an arresting gear wire and another perfect landing will be logged for a well-trained Navy pilot aided by the optical glide path indicator. (*From new 12-page Brochure DCS-6, Control Instrument Co., Inc., Burroughs Corp.,* 6071 *Second Ave., Detroit* 32, *Mich.*

For this literature circle **101** on inquiry card.

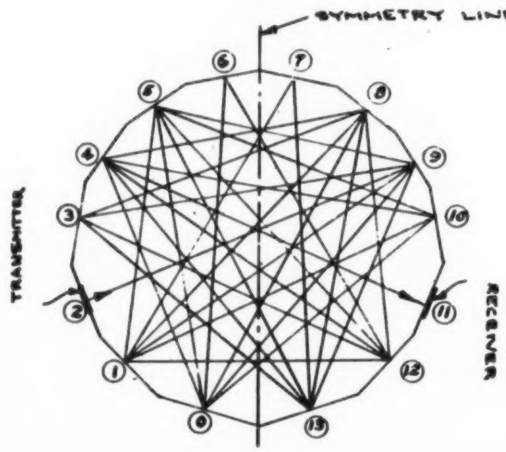
Ultrasonic Delay Lines

The delay line has three basic elements. The first of these, the transducer, is used to convert electrical energy into sound, and back again. Two transducers are usually used.

Because quartz crystals are plentiful and can be readily manufactured up to 60 MC, these are preferred as transducers.

The second element is the delay medium itself. The sound travels from one transducer to the other and the delay time is determined by the total path and the velocity of sound in the medium. Because there is a ratio of 1/200,000 between acoustic and electro-magnetic waves, a great deal of compression in space is achieved.

In multiple symmetry designs, many of the regular facets are tilted and it is then possible to have the sound beam strike the same points several times. Actual paths of this type based on 15-sided polygon is



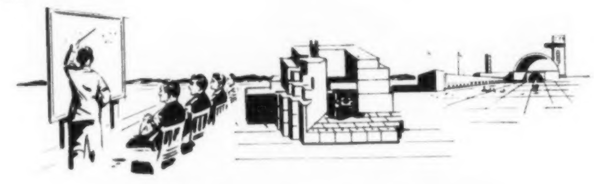
shown. This has been most widely used and in the 1000-microsecond size can be cut from a 5.6" disc—¼" thick, weighing ½ lb. With a 15-mc carrier, all secondaries will be 40 db below the main delay over a 7-mc band width. (*From new 4-page bulletin, Arenberg Ultrasonic Laboratory, Inc.,* 94 *Green St., Jamaica Plain* 30, *Mass.*)

For this literature circle **102** on inquiry card.

D. A. R. T.

The Daystrom Reactor Training Center is a new program for reactor construction and training. To help overcome today's critical shortage of trained nuclear engineers, reactor operators and instrument technicians, Daystrom, Inc., has established extensive new educational facilities at West Caldwell, N. J. Daystrom's center of specialized industrial training is designed to be a major force in implementing the Government's, much publicized, "Atoms for Peace" Program.

An important adjunct to the D.A.R.T. (Daystrom Argonaut for Research and Training) Program of reactor manufacture and operator training, is the use of a critical 10 kw research and training reactor, located on the premises, for practical student instruction and application.



The D.A.R.T. Research Reactor

Some of the experiments possible using the D.A.R.T. Reactor include:

1. Pile oscillator measurements and danger coefficient studies in the central thermal column.
2. Exponential experiments at the top of the assembly with an available flux of 10^{11}.
3. Critical mass determinations on the annular core.
4. Fuel standardizations and instrument calibration experiments.
5. The irradiation of fuel elements.
6. Graphite reflected critical experiments.
7. Mapping of microscopic flux in lattice cells.
8. Measurements on thermal migration properties, shielding studies and exponential experiments. (*From new 4-page bulletin, Daystrom Nuclear, Div. of Daystrom, Inc., P. O. Box* 347, *West Caldwell, N. J.*)

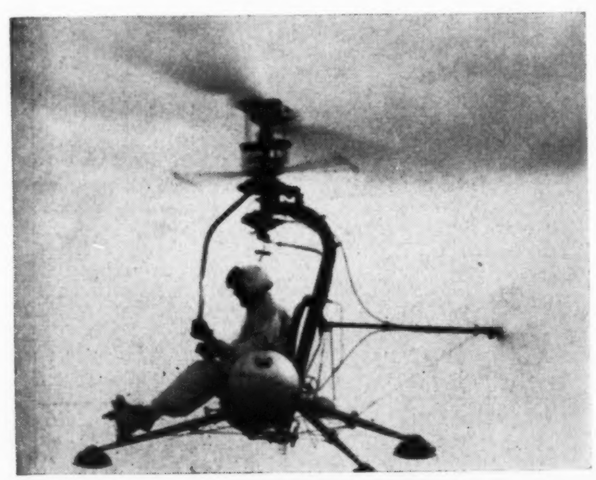
For this literature circle **103** on inquiry card.

Unified R & D

A good example of what the services can do through coordinated effort is found in the joint program of the Office of Naval Research and the Army. A group of Army aviation projects that are now being handled by the Air Branch of ONR are of mutual benefit to both the Army and the Navy. Primarily, the projects are those of the Army Transportation Corps, which has the responsibility for all Army aviation. Because the principal interests of the Army in aviation are reconnaissance and transport, the research and development projects managed by the Air Branch of ONR are aimed at a group of special problems in these fields.

A great many of the projects recently undertaken by the Air Branch of ONR were supplied wholly or partly with funds by the Army Transportation Corps. Problems dealing with boundary-layer control, stability and control are a few research areas in which ONR and Army interests coincide.

Study projects being pursued under this arrangement include helicopter boundary-layer control, helicopter design, and five projects on design and comparison of vertical take-off-and-landing aircraft. One project includes development of the Flying Platform, which has now progressed to the testing stage. Although work on the Flying Platform was originated by ONR, it has created wide interest and is now supported by the Army.



Volscan Eliminates "Stacking"

VOLSCAN, a terminal air traffic control system, is today ready and able to convert a cloud of randomly arriving aircraft into an orderly, safe procession ready for landing . . . without the time-consuming and wasteful expedient of "stacking."

Supersonic jets may require as much as a 50-mile long block of space for their terminal approach. A successful air traffic control system therefore must assign each incoming aircraft a "cube of space" which is reserved exclusively for its use. VOLSCAN automatically assigns the space, follows the aircraft as it moves within the cube, and brings it to an "entry gate" where an existing and adequate Instrument Landing System or Ground Controlled Approach takes over.

As the VOLSCAN radar sweeps the sky, an approaching aircraft first appears as a "blip" on the Plan Position Indicator of the Operating Console. The

Spotting the "blip."

"blip" is spotted with a light gun (See Pic) and immediately VOLSCAN's electronic "brain and memory" go to work. The VOLSCAN memory unit, a part of the Automatic Tracking System, follows the plane as its "blip" moves on the radar screen. Meanwhile, an operator contacts the aircraft by radio and obtains additional information which is fed into the electronic scheduling and computer system.

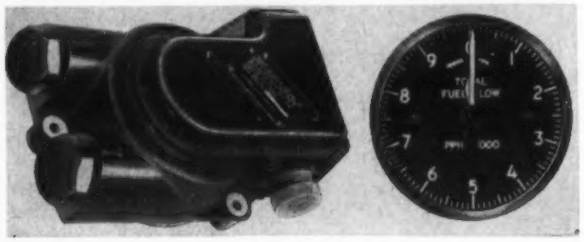
The analog computer is an electronic traffic manager which has stored up within it the correct answers to every possible landing approach problem that may arise. Since the computer actually has the answer before the problem is submitted, it takes only a fraction of a second for it to compute the correct approach instructions . . . in effect, to assign a cube in space. Heading and altitude instructions are then delivered by radio to the pilot.

As the pilot follows the instructions relayed from VOLSCAN, the automatic tracker follows the aircraft, feeding positional information to the computer. If the pilot does not obey a flight instruction, automatic adjustments are made in later instructions to compensate for this error, keeping him on schedule. (*From new* 4-*page Brochure C*-102, *Avco Mfg. Corp., Crosley Div.,* 1329 *Arlington St., Cincinnati* 25, *Ohio.*)

For this literature circle **104** on inquiry card.

Jet Aircraft Instruments

Shock mounted and hermetically sealed, this instrument is a dual-channel servo amplifier for use in airspeed and Mach number computer systems. Operating



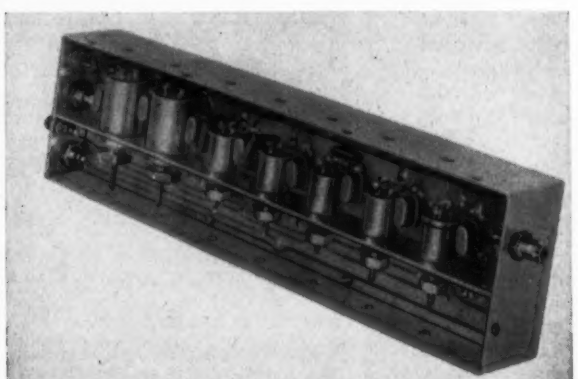
from a single-phase 115-V, 400-cps power supply, it amplifies synchro output signals to drive servo motors for the true airspeed and Mach number servo loops of the Norden-Ketay type IM-1 indicator. Each channel has a 90° phase shifter, two amplification stages, one phase splitter and one push-pull amplifier stage.

Specifications: Weight—2.75 lb, Power input—115 V, 400 cps, 56 VA max; Output—26 V, 400 cps; Alt. range—1,000 to +80,000 ft; Meets MIL-A-8026 and MIL-E-5272. (*From new 4-page Bulletin 424, Norden Ketay Corp., Instrument and Systems Div., Milford, Conn.*)

For this literature circle **105** on inquiry card.

IF Amplifiers

The series 80 amplifiers are transistorized versions of the IF 62 subminiature amplifiers and are intended for prototype work in new system designs. While normally designed for a 2 mc bandwidth at a center frequency of 30 mc, they can be supplied at other center frequencies and bandwidth on special order.



The IF 80 B uses six stages of grounded base circuitry with an emitter follower output stage.

Model IF 80 B: Gain—100 db; Center Frequency—30 mc; Bandwidth—3 mc; Power Requirements—28 volts @ 1 watt; Gain Control—external; Dimensions—8" x 2¼" x 1¼". (*From new 6-page Bulletin, Lel, Inc., 380 Oak Street, Copiague, L. I., N. Y.*)

For this literature circle **106** on inquiry card.

MA TRENDS

In a recent address before a joint meeting of an AIEE-IRE student branch, Mr. H. H. Hoffman, of Hoffman Electronics Corporation, Los Angeles, estimated that military electronics would reach the following levels by 1965:

Military Electronics Forecast

Year	Total Defense, Billions	Government Electronics to Total Defense, Per Cent	Military Electronics, Billions
1955	$33.2	7.4	$2.5
1960	37.0	8.8	3.3
1965	40.1	9.9	4.0

Mr. Edward P. Curtis, Special Presidential Assistant for Aviation Facilities Planning, has predicted air traffic will double or triple by 1975 and that the limiting factor in growth will be adequate facilities, including electronic instrumentation, to handle the traffic.

One year ago, the Federal Airway Plan called for equipment expenditures of approximately one-quarter billion dollars for 1957-1961. An expanded and expedited revision has recently been announced which now calls for $810 million for 1957-1962. The increased figure is due to jet transport service, 1230 VORTAC navigation ground installations, 115 airport surveillance radars, and a sixth year of work not previously included.

National association of business administrators recently instituted a "business management war-game" as a training measure for executives. It was based on the "war games" played by military commanders for exercise in command situations. It also has been proposed that electronic data processing systems be utilized in Army War Games to assure full consideration of all factors.

CAA reports an increase of 13% in aircraft operations (takeoffs and landings) over 1955. The number of fix postings (reports by pilots in air on instrument flight over reporting points) increased 22%, and the number of instrument landings increased 29%.

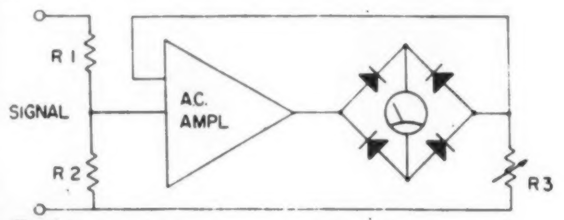
Nuclear industry for 1957 is estimated to total $543 million, with $33 million in instruments, power reactor construction $120 million, research on other than power reactors $30 million and military reactors $140 million. Mining and milling of uranium accounts for $220 million. Industrial savings through the use of radioisotopes are $250 million a year.

The magnetic amplifier market, starting from scratch after World War II, is now an estimated $100 million. First exclusively military, the commercial portion now approximates 40% and is increasing.

AC and DC VTVM's

A and E Series

The A and E Series VTVM's are miniaturized, panel-mounting versions of the familiar laboratory instrument. They provide all the advantages of electronic measurement of AC voltages, and yet do not exceed the panel area required for standard panel meters. Standard ranges from 10 MV to 300 V AC Accuracy: 2%.

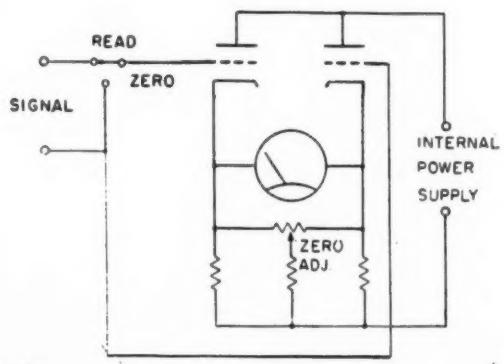


B Series

Designed for military applications, the B Series ruggedized miniature AC Vacuum-Tube Voltmeters are capable of withstanding temperatures greater than 160°F and utilize a meter movement capable of withstanding the shock of a 400-pound sledge hammer. Standard ranges from 10 MV to 300 V AC. Accuracy: 2%.

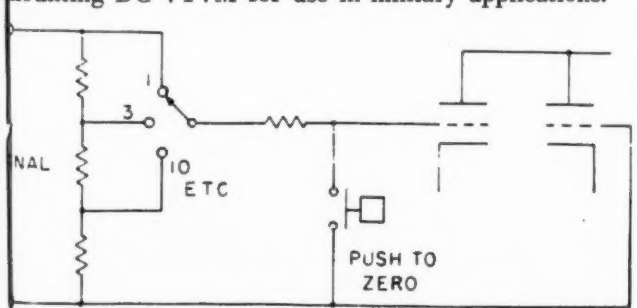
F Series

The F Series of complete DC Vacuum-Tube Voltmeters also can be mounted in operating equipment without exceeding the area required by standard panel meters. Standard ranges from 1 V to 300 V. Accuracy: 2%.



G Series

The G Series is a ruggedized, miniature, panel-mounting DC VTVM for use in military applications.



Its unique packaging offers the utmost in weight and space savings. Standard ranges from 1 V to 300 V. Accuracy: 2%. (*From new 32-page Catalog* 57-110, *Trio Laboratories, Inc., Seaford, L. I., N. Y.*)

For this literature circle **107** on inquiry card.

Bill Waddell discusses ANALOG/DIGITAL CONVERSION

For the past few years one of the most serious concerns in systems design has been the development of equipment eminently suited to "link" the analog input to the digitized output assemblies of the system. Examples of such links are to be found in radar recording problems in the missile test field, in the control of machine tool operations and, most recently, in data logging in the petrochemical and chemical processing industries. In these and similar instances, there has been a conscious striving to produce highly specialized pieces of conversion equipment in an attempt to adapt the system to the particular control problem at hand.

This striving has also led to increasingly frequent discussions of analog to digital conversion in engineering circles. Such discussions have stimulated interest in, and have actually succeeded in clarifying, basic problems faced by the engineer in producing units suitable for the digitization of specific function variables.

However, contending for attention along with the requirement for restricted-purpose conversion equipment, are the types of analog functions requiring to be digitized. These have continuously increased in numbers, in complexity, and in the imposition of increasingly severe criteria for reliability. To illustrate, systems today are successfully coping with shaft rotations, linear displacements and the complete gamut of electrical signals. A few systems have been built where pressure, temperature, and flow variables have been directly converted.

In the past the tendency has been to design the analog to digital converter and then assemble systems around the converter block. Examples of this approach are to be found in the handling of high-speed serial binary digits from input voltages, and in shaft converters containing cyclic codes requiring complicated translations before the outputs are readily adaptable for further processing. In order to achieve suitable solutions in such cases, it became necessary to introduce auxiliary equipment which frequently turned out to be much less reliable than the digitizer. This led, therefore, to more highly complicated and costly systems rather than significantly simplifying the basic analog to digital converter.

The current approach is to engineer a "link" integrating the components directly into the system. Only in this manner can they be properly weighted to assume their true and economical function. This has resulted in consciously avoiding marrying, for instance, a 5,000 sample per second analog input to a converter capable of spewing out 50,000 samples per second. Or by the same token, feeding 50,000 samples per second into subsequent processing components not adequately provided with control equipment and/or direct methods for recording such rapid outputs.

Bill Waddell, systems input-output specialist, discusses analog to digital conversion.

The present awareness of the problem, however, makes for a most encouraging outlook in the foreseeable future. Design break-throughs are bound to integrate the analog to digital conversion step into its proper and logical relationship to the total system. Systems will then become less complex and significantly more reliable, which undoubtedly will rapidly result in unfolding important new fields suitable for control applications.

By applying the latest proven techniques, our well-qualified staff at Daystrom Systems is prepared to take single responsibility of assembling and installing a system to meet your needs. We are currently compiling a file of new applications and papers on various parts of systems, both industrial and military. If you are interested in receiving the file and periodic additions, please write us.

For more information circle **15** on inquiry card.

ARMY AUTOMATION

FIG. 1. RADAR TRANSIT measures distances up to 50 miles precise to a few feet by bouncing signal between itself and distant identical station. Antenna on collapsible mast "sees" through foliage, bad weather and darkness. Transmitter-receiver and computer is in rear jeep compartment.

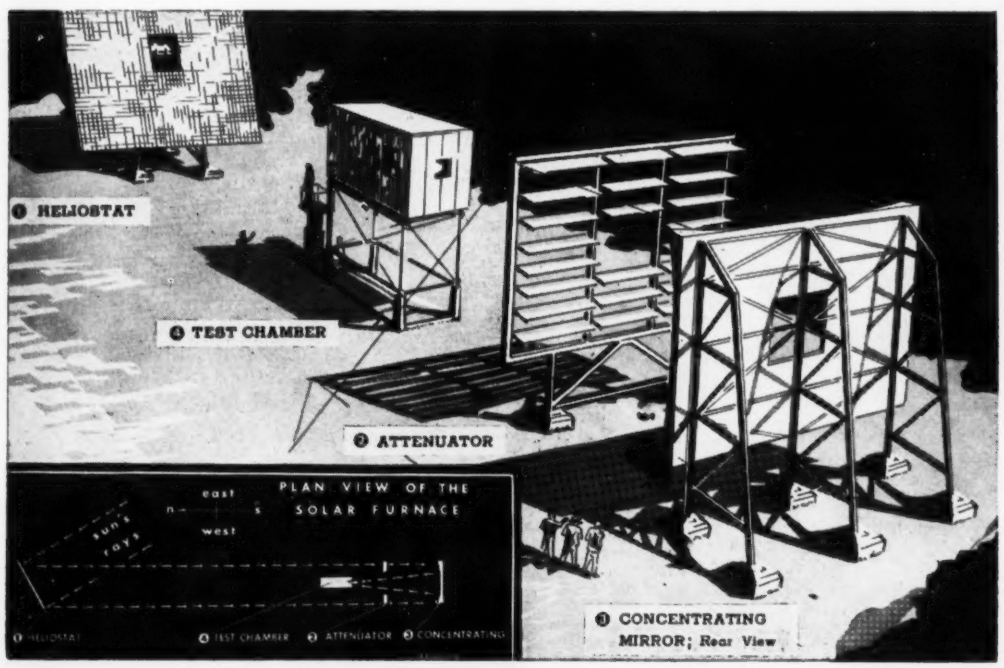


FIG. 2. SOLAR FURNACE for testing heat-resistant materials to be constructed at the Quartermaster Corps Research and Development Command, Natick, Mass. Travel of the sun is automatically tracked by the heliostat.

FIG. 3
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FIG. 4
bat pic
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FIG. 3. **GI WITH AN/PPS-4 RADAR** spots and plots single moving enemy half-mile away in darkness or fog; vehicles, or large groups at greater distance. This Electronic sentry, developed by Sperry Gyroscope Co., uses audio indication to achieve miniaturization and rugged construction.

FIG. 4. **SOLDIER-SCOUT SENDS LIVE VIDEO** combat pictures to command post with 8-lb tactical T-V camera built by Radio Corporation of America; 47-lb transmitting station with battery power is carried in pack.

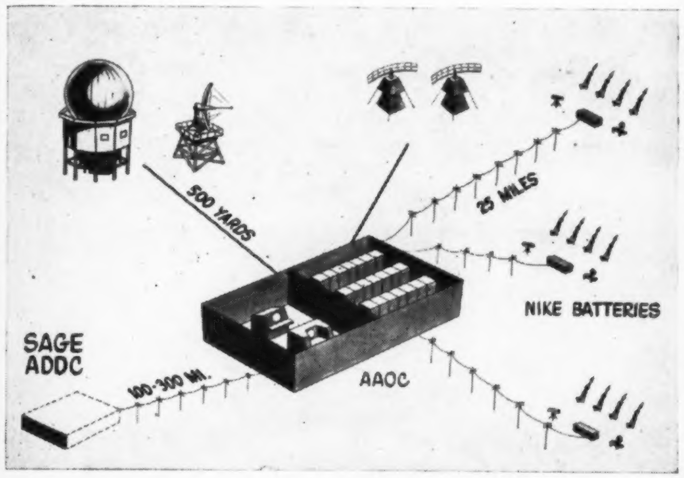

Fig. 5. Electronic control of Nike batteries is shown by schematic diagram of Missile Master system. At right, radar console operators use photoelectric light guns placed against the screens to automatically transmit data to computers.

Fig. 6. Flight of missiles at White Sands Proving Ground is followed by telescopic tracker which automatically transmits data to computers.

Fig. 7. Helmet radio, smallest 2-way combat radio, comprises these two units which snap into special helmet to make a complete communications set in a hat.

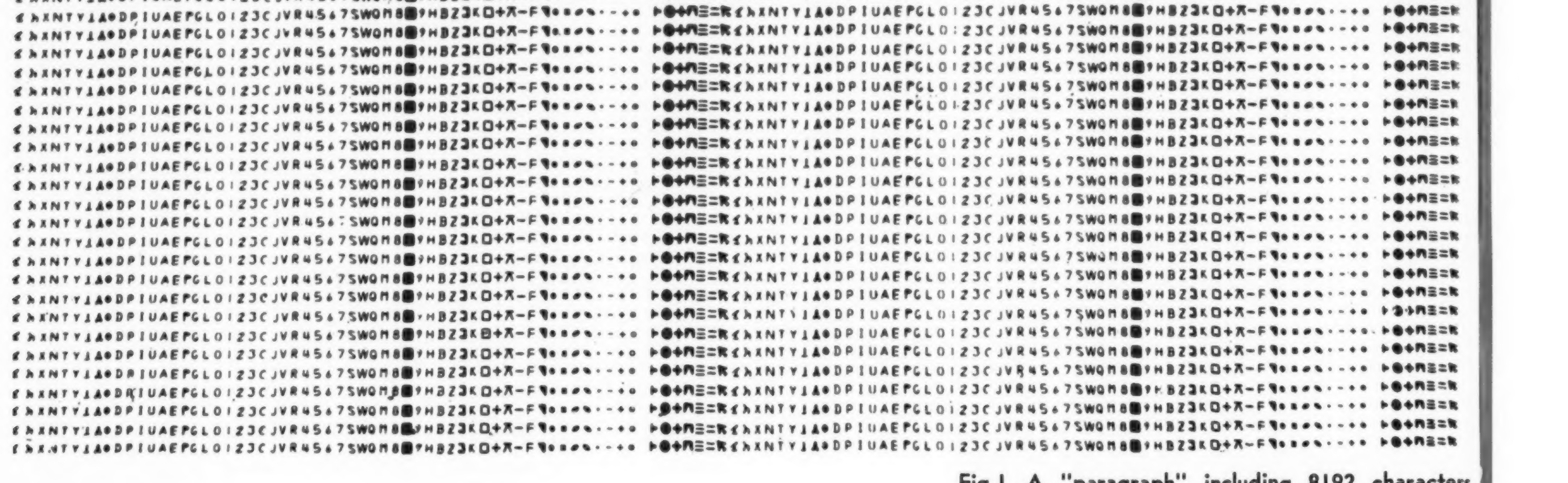

Fig. 1. A "paragraph" including 8192 characters recorded in approximately 520 milliseconds.

CHARACTRON Sh

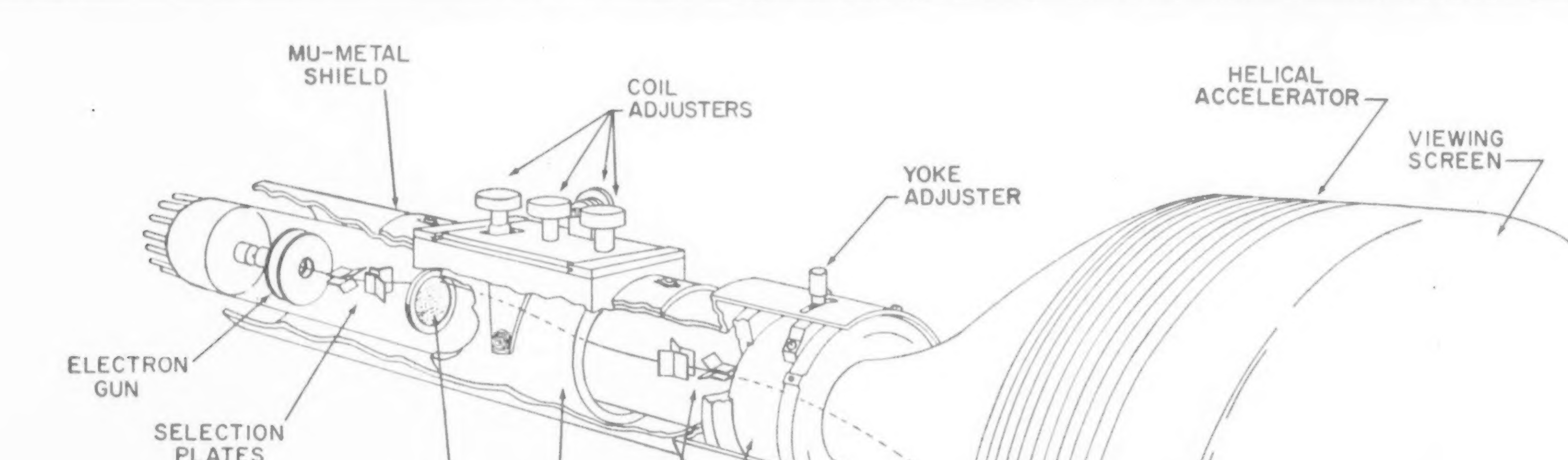

Fig. 2. C19K tube and coil assembly.

Fig. 3. Typical matrix requires specialized photo engraving as relative sizes and shapes of the characters and the sizes and uniformity of the apertures through which the electron beams are extruded determine the readability of the characters formed on the screen of the tube.

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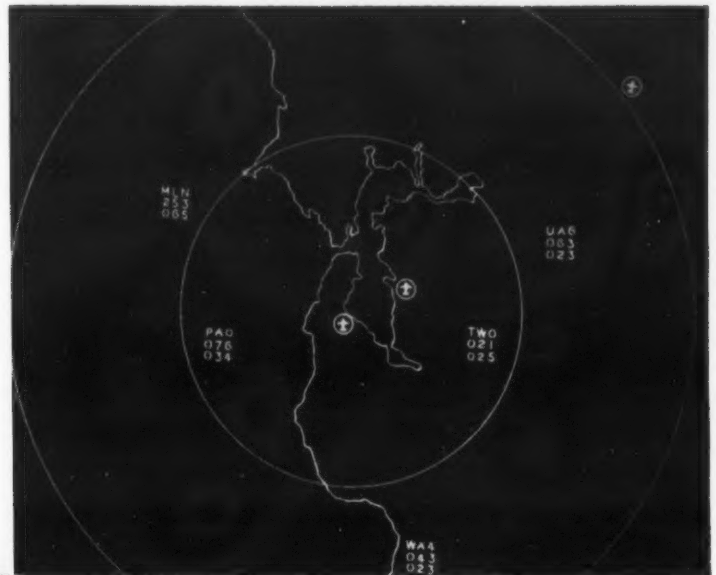


Fig. 4. Air traffic control display on the C19K, 19" dia. tube.

Shaped Beam Tube

Fig. 5. Joseph T. McNaney, inventor of the CHARACTRON shaped beam tube.

The CHARACTRON* shaped beam tube fills a need for high-speed readout from computers or other data sources having readout rates of 5,000 to 20,000 characters per second. It can be used as a page-type recorder for readout and storage, intervention for computer checking, or recording or immediate reading of high-speed communications. When used as PPI scope, signals are identified by groups of characters for special surveillance problems, air traffic control, etc.

Donald T. Olmsted

Stromberg-Carlson—San Diego

PATENTED by Joseph T. McNaney (Fig. 5) in the early 1940's, the CHARACTRON shaped beam tube was left undeveloped as no existing equipment required its recording speed. The advent of high-speed computers revived interest in the tube as a simple computer readout device, and development was resumed in San Diego in 1950. Improved accuracy in positioning the characters with a high degree of clarity and brightness has so improved the tube that it is now also suitable for combined target identification and PPI use (Fig. 4).

During recent years many methods have been evolved for writing or printing characters on the screens of cathode ray tubes. In some of these methods the electron beam moves across the face of the tube to produce a trace similar to writing with a pencil. This requires a continuous and ordered change of voltages applied to the deflection plates of the tube. Others produce the characters by a raster scan that operates in a manner similar to facsimile reproduction. The CHARACTRON shaped beam tube forms all parts of each character simultaneously by extrusion of the electron beam through a stencil-like mask, then places that character at any desired place on the face of the tube. The maker says it provides the brightest, smallest and easiest-generated characters that can be displayed on a cathode-ray tube.

Operation

As the basic principles and construction of all available CHARACTRON shaped beam tubes are the same, a study of the function and structure of the C19K tube (Fig. 2) is sufficient for understanding the operation of all tubes. The electron gun, which includes the cathode, focusing anodes and blanking grid, produces the beam and acts as a shutter to turn it on and off.

The tube is blanked off during the few microseconds required to stabilize the selection and positioning voltages. When the blanking voltage is removed, a choice of one of eight steps of regulated voltage applied to the horizontal and vertical selection plates directs the beam to the proper character on the matrix. A typical matrix, shown in Fig. 3, acts as a minute electron

*CHARACTRON is a trademark that is registered in the U.S. Patent Office by Stromberg-Carlson, a Division of General Dynamics Corporation.

The Author

DONALD T. OLMSTED has a B.A. in Physics, 1928, Colo. State College of Education. During early World War II he served as a scientist with the Signal Corps Training School at Laramie, then as a staff member in the Radiation Laboratory of MIT. As Lieutenant, U.S. Naval Reserve, in 1944 he served with Bu Ships and the Naval Research Laboratory on tropospheric propagation research. Since 1946 he has served as engineer in the Wave Propagation Group, Naval Research Laboratory, on radio interference reduction for Bureau of Yards & Docks; engineer-in-charge of the Cornell University Solar Radio Observatory; with Land Air Corp. on Solar Radio Research; and, from 1953 to 1956, Communication System Superior and Consulting Engineer for the General Electric Advanced Electronics Center. Mr. Olmsted is now Head, Systems Engineering, Stromberg-Carlson, San Diego.

Fig. 6. Model 70B display console uses 19" shaped beam tube.

Fig. 7. CHARACTRON computer readout equipment, Model 100.

Fig. 8. Demountable vacuum tube assembly used for electron optics research.

stencil. It is made of a special alloy with all symbols engraved within a square area slightly less than one-fourth inch on a side. Sixty-four characters are etched in eight horizontal rows of eight characters per row. The choice and arrangement of characters and symbols in the matrix can be varied to meet the particular needs of any custom application.

The convergence coil redirects the now off-center beam back to the center of the tube where it is realigned by the reference plates. The deflection yoke selects the spot on the face of the tube where the beam will strike and activate the phosphor to display that character. The helical accelerator acts as an intensifier to improve the brightness of the character.

Coding

The simplest and best method of selecting characters is to bring all information from outside sources in binary coded form. Three binary bits provide eight choices for vertical selection and three more bits provide horizontal selection. Thus a total of six bits is required for the selection of each character.

Ten bits of binary input to the decoding amplifying circuits controlling the deflection yoke offers a choice of any one of 1024 possible horizontal positions on the face of the tube for the extruded character. A second set of 10-bit codes provides the same selection of the vertical position. The precision required in this positioning prompted the use of electromagnetic instead of electrostatic deflection.

In addition to externally selected and coded display positions, sequences or combinations of position also can be generated locally. By using this feature, information can be displayed on the tube using only six binary bits for each character.

Display Versatility

The characters may be selected and displayed at rates up to 20,000 per second. They may be organized in lines, as on the page of a book, or assembled in groups or formats and placed in any desired location. Each character may be flashed only once and photographed in real time to make up a complete page, or the characters may be repeated 15 to 20 times per second to produce a continuous non-flicker display. Parts or all of a display may be moved from one position to another at any desired rate.

The CHARACTRON shaped beam tube also has all the characteristics of a standard cathode-ray tube. By directing the beam through a hole in the matrix, instead of through a shaped character, the deflection coils can be used for the standard electronic method of producing a PPI sweep. By a system of time-sharing, a combination radar display and display identification can be produced.

Tube Sizes

Two sizes of CHARACTRON shaped beam tubes are now available as shelf items. For air traffic control, surveillance or direct observation of output from any type of data-processing equipment the large 19" tube, C19K (shown on the cover) is most suitable. The console shown in Fig. 6 uses the C19K and is designed as a basic unit for experimental work involving any of the directly-observed presentations. For permanent record purposes, photographic recording, or projection, the 7-inch, high intensity, short-persistence tube is most suitable.

The equipment shown in Fig. 7 uses the 7" tube and provides direct recording for speeds as high as 20,000 characters per second, eliminating buffer storage or intermediate tape recordings. This is particularly useful for computer readout, human intervention in computer operation, storage examination, or data-processing outputs that require direct recording of information. The equipment provides both permanent storage and immediate visual display for program monitoring. It also can record data in tabular form and plot curves complete with titles, scales, grid patterns and other interrelated information.

Research

If research now under way to change from electromagnetic to electrostatic position selection is successful, several microseconds settling time now required for electromagnetic deflection will be eliminated, and a recording rate of 100,000 characters per second may be attained. Electron optics research, continuously under way, uses devices such as the demountable vacuum tube (Fig. 8). Matrix research efforts point toward an increase to a possible maximum of 256 available characters (16 columns and rows), each being selected by a combination of eight binary bits.

New Applications Planned

Present and past uses of the CHARACTRON shaped beam tube have included computer readout, computer intervention and storage inspection, digital transfer of data and information, and various types of surveillance including ground, air and sea.

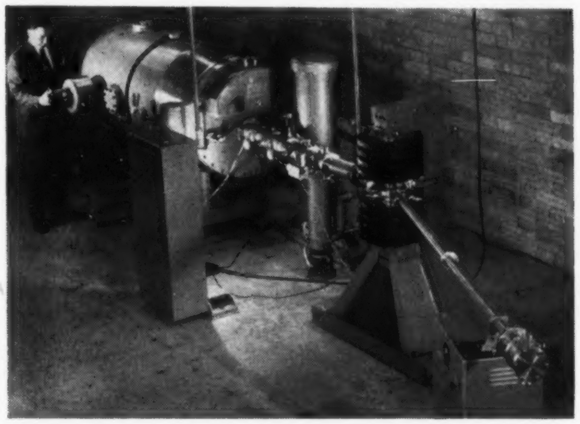
Future planning includes accepting output of any data processing equipment. Computer, communication, radar and beacon data may be displayed either singly or in combinations for direct observation, recorded for storage, or immediately projected. Characters can be displayed at the rate of a few microseconds per character. These may be organized as written columns and pages of information or as identifying groups that are included on radar presentations or maps. In the latter case, these groups of characters may be moved in synchronism with the items under observation and changed as the information changes.

In summary it should be noted that the CHARACTRON shaped beam tube "prints" each character on its screen as a single operation. This is the secret of its high speed and this principle also simplifies the input equipment required. In addition, it is capable of operation as a standard cathode ray tube such as a radar PPI or even as a television tube. By a time-sharing process, combinations of these operations may be displayed and recorded as desired.

Redstone Arsenal—Army's Guided Missile and Rocket R & D Center

AN ALERT is sounded in the control shack. Immediately test crews spring into action, Army Nike launchers and radar controls swing into position. The missile is launched and moments later the attacking aircraft is destroyed. This time the "attacker" was a drone and the operations were a test. However, it could have been real and we would have been ready.

Army Ordnance is ready also with anti-tank missiles such as DART, tactical artillery support with Honest John, Little John, Corporal, Redstone and soon, Jupiter.



Two-million-volt Van de Graaff particle accelerator similar to that being installed at Redstone Arsenal.

Redstone Arsenal, the Army's guided missile and rocket installation, has research laboratories to generate the long range information and ideas required to guarantee missile superiority in the future. The laboratories have physicists, chemists, engineers and mathematicians engaged in research in aerodynamics, combustion, electronics, solid state physics, nuclear physics, dynamics and mathematics.

The laboratories make available to investigators supersonic wind tunnels, a liquid helium cryostat, nuclear magnetic resonance equipment, optical and mass spectrometers, radioisotopes for gamma and neutron sources, microwave equipment, high-temperature furnaces, a rapid rate tensile testing machine, high-resolution microscopes and a wide variety of instrumentation associated with this equipment.

A tool for missile and rocket research recently acquired is the new 2-million-electron volt Van de Graaff particle accelerator (see illustration) built by the High Voltage Engineering Corporation, Burlington, Mass. Research programs using this equipment will be directed by James E. Norman, chief of the research laboratories.

For more information on the particle accelerator, circle **201** on inquiry card.

Printed Circuitry

III Design Factors

Printed circuits are more than conventional circuits with printed wiring. Consideration of base material, size and width of conductors, type of conductors, and cost of fabrication are all necessary as early as the circuit design stage.

ALLAN LYTEL General Electric Company

THE INKED DRAWING, which is the basis for the final circuit design, is usually the result of a number of layout sketches. These trial layouts are made repeatedly until the most direct and simple position of the final wires is decided upon. Many factors, such as (1) required current, (2) number and types of required components, (3) temperature of operation, (4) use of the circuit and (5) quantity of units needed are evaluated as they affect (1) conductor width, thickness and spacing, (2) hole size, shape and spacing, (3) component placement and lead dress, (4) circuit terminations and (5) materials and production means.

In this chapter we describe these factors and present recommended practices now in use in industry.

Master Drawing

After a satisfactory design is completed, a master drawing is inked on a good stable white stock which will not change in size because of weather or other factors (Fig. 3-1). A flat black ink must be used because reflections from the surface of glossy ink could prevent accurate reproduction. It is necessary that all lines be sharp and clean for best results.

Drawings are made 2 to 3 times larger than the final circuit because this enlarged scale permits closer tolerances in the final product as well as sharper reproduction; for example, an error of 0.048″ in a large drawing will be only 0.016″ after a three-to-one reduction. The scale and also the final size of at least one dimension of the final drawing or circuit size is required on the drawing. Register marks also are required.

Lettering, such as trade names or code letters, should be sized so that after reduction the lines are not thinner than 0.015″ and the letters are clearly legible.

Even layout can be standardized. Fig. 3-2 shows one common tool that is used in laying out over 100 different printed circuits for mass production. This is done by using one common aluminum plate several times the finish size, with all holes in the plate corresponding with holes punched by a machine tool. Terminals and conductive paths are put on with plugs and tape. Unused holes are masked out of the circuitry, but also are perforated on the final boards by the machine tool.

Table 3-1 illustrates the range of accepted values for conductor width, thickness and spacing. For example 0.01″ is a minimum value for conductor width and spacing, while 0.060″ is recommended both for spacing and width. Conductor thickness (discussed in the following section) depends in part on the thickness of the base material.

Capacity of printed wiring is a function of board thickness and board material, as shown in Table 3-2.

Fig. 3-1. Drawing the enlarged master for a printed circuit. (Photo courtesy Insulated Circuits, Inc.)

ETCHED COPPER PROCESS	CONDUCTOR THICKNESS	BASE MATERIAL THICKNESS	WIDTH OF CONDUCTOR	SPACING OF CONDUCTOR
Range	0.0013" (1 oz.) 0.0027" (2 oz.) 0.0040" (3 oz.)	1/32" 3/64" 1/16" 3/32" 1/8" 1/4"	0.010" min.	0.010" min.
Recommended for General Practice	0.0013" (1 oz.)	1/16"	0.060"	0.060"

Table 3-1. Copper conductor thickness, width, and spacing. (Table courtesy Aerovox Corp.)

APPROX. CAPACITY PER UNIT LENGTH OF CONDUCTOR: MMF/inch

Board Thick.	Phenolic XXXP	Phenolic XXP	Phenolic XP	Melamine	Teflon
1/32	1.05	0.88	0.79	1.25	0.33
1/16	0.85	0.71	0.64	1.10	0.26
1/8	0.72	0.60	0.54	0.90	0.22

Table 3-2. Copper conductor capacities. (Table courtesy Techniques, Inc.)

Pressed Silver Wiring	Etched Copper Wiring	Base Material	Dissipation Factor at 1 mc.	Moisture Absorption % for 24 hrs.	Dielectric Constant at 1 mc.	Maximum Operating Temperature Deg. C°	Punching Quality	Flexural Strength PSI	Approx. Cost Ratio XXXP = 1
X	X	XXP Lam. paper-base phenolic	.04	1.8 max.	4.6	125	Very Good	17,000	0.9
X	X	XXXP Lam. paper-base phenolic	.03	1.0 max.	4.5	125	Good	23,500	1
X	X	Grade LE linen phenolic	—	1.95 max.	—	125	Excellent	15,000	3
*X	X	Nylon Base phenolic	.03	0.6 max.	3.3	75	Excellent	16,000	3
	X	Melamine glass base	.03	2.7 max.	6.8	150	Poor	55,000	2
*X	X	Epoxy glass base	.022	.20	4.9	175	Good	50,000	4
	X	Silicone glass base	.015	.20	3.9	200	Poor	40,000	6
X	X	Teflon glass base	.0007	.03	2.6	250	Poor	13,000	20
X		Polystyrene	.0002	.05	2.5	85	Very Poor	17,000	3
X		Methacrylate (Lucite)	.03	.40	3.3	85	Very Poor	17,000	2

Table 3-3. Base material table. (Information compiled in the above table was obtained from the following sources, NEMA, Aerovox Research Dept., and suppliers of base materials.)

(*Subject to design details. Check (X) indicates availability of base materials.)

Base Materials

Laminated phenolic boards are commercially available in the following thicknesses: 1/64″, 1/32″, 3/64″, 1/16″, 3/32″, 1/8″, 3/16″ and 1/4″. Several base materials are used; paper is common. Usually the boards are a laminated material coated or impregnated with a thermosetting* phenolic resin binder. High pressure (1500 psig) applied under conditions of high temperature (325°F) produces a single hard sheet of great strength. Electrical properties are rated by NEMA (National Electrical Manufacturers Association) as X, XX, or XXX. A suffix P is used to indicate that the material has good punching qualities. Insulation resistance and dielectric strength increase in grades X through XXX along with the cost of the material.

Table 3-3 is a tabular list of base-material properties for the following four general classes.

1. *Phenolic paper-base laminates.* XXP is a paper-based phenolic material of electrical grade. It has good mechanical strength and may be punched while hot. XXXP is the same type of material but is used where low dielectric losses under high humidity conditions is important. It has high insulation resistance and good hot-punching characteristics.

2. *Phenolic fabric-base laminates.* This is usually a cotton-base material suitable for machining and fabrication of special shapes. It has good electrical properties and excellent mechanical characteristics. This material is available in very thin sheets. The phenolic Nylon has a very high insulation resistance under high humidity conditions, excellent impact strength, and excellent electrical qualities.

3. *Glass fabric-base laminates.* Melamine glass is both arc and heat resistant. Epoxy glass has the greatest mechanical strength of the materials listed. Silicone glass has a smaller dissipation factor than epoxy, and Teflon glass is used where there are very high operating temperatures or where dielectric characteristics are very important, as with microwave circuits.

4. *Thermoplastic materials.* Polystyrene is used where an extremely low-loss factor is required. Conductors may be applied to flat sheets, molded parts, or extruded parts. Methacrylate has properties somewhat inferior to Polystyrene but is used where the change in mechanical properties during aging must be kept small. Methacrylate is also known as Lucite. All of these thermoplastic materials have low operating temperatures (they melt when reheated), poor punching qualities, and are suitable only for die-stamping, not for etching.

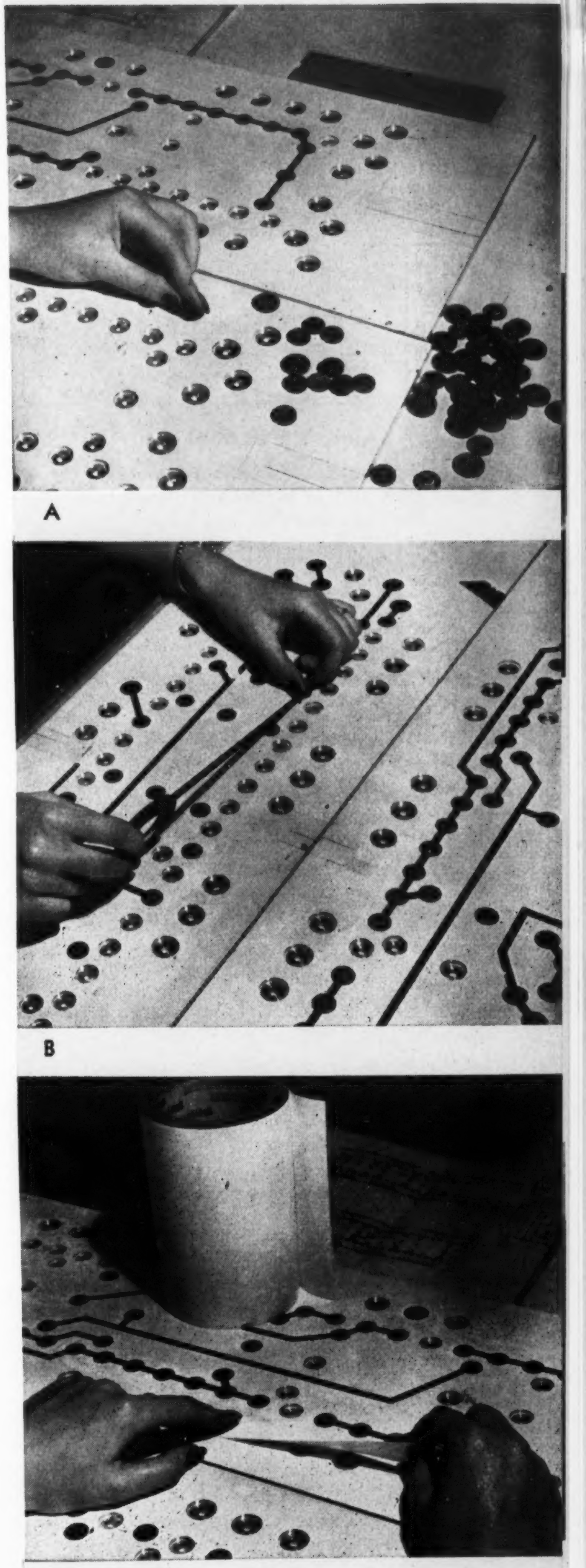


Fig. 3-2. Pre-drilled standard aluminum layout board. A shows inserting circles where holes will be used for connections. B shows laying down conductive paths with tape. C shows masking out unused holes. (Photos courtesy Photocircuits Corp.)

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* After curing, the plastic sheets will not melt when reheated.

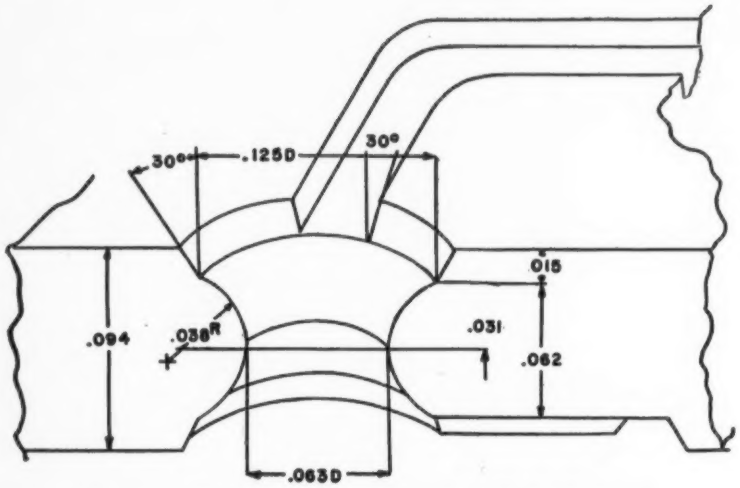


Fig. 3-3. Typical cross section of 1/16" dia hour-glass hole in a die-form panel. (Drawing courtesy Die-Form Circuits, Inc.)

Oz/sq ft	Thickness in Inches
0.5	0.0007
1	0.00135
2	0.0027
3	0.0040
5	0.0068
7	0.0094

Table 3-4. Available weights of copper foil.

RESISTANCES FOR COPPER-CLAD PRINTED CIRCUITS

Ohms per inch at 20° C for 100% Conductivity Copper

Line Width	.0013" Copper	.0027" Copper
1/4"	.002	.0009
1/8"	.004	.0018
1/16"	.008	.0035
1/32"	.016	.007
1/64"	.032	.015

Table 3-5. Copper resistance as a function of width and thickness. (Table courtesy Aerovox Corp.)

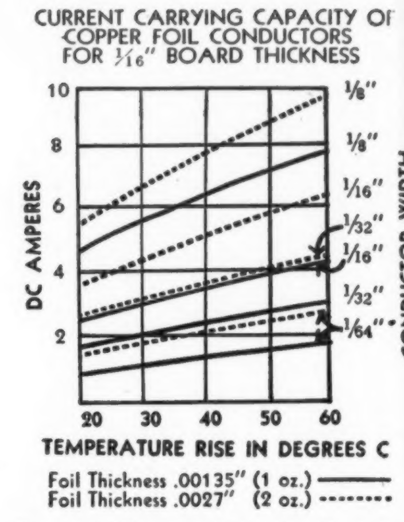


Fig. 3-4. Temperature rise in copper printed wiring. (Drawing courtesy Aerovox Corp.)

Bond Strength

The bond between the conductor and the board is a function of the base material and adhesive. Originally copper foil was bound to the laminated base after the base was manufactured. Now techniques have been developed which have the adhesive-coated copper foil made part of the laminated base when it is first cured under heat and pressure. Bond strength is measured in terms of the force, in pounds, required to peel back a 1"-wide strip of the conductor foil. Bond strength, or peel strength, as high as 20 pounds has been obtained for a 1" strip of copper-clad phenolic material.

Molded Boards

A form of molding recently developed for printed circuits* permits variations in conductors and molded holes. The panels can be made from any insulating material which can be molded, such as mica-filled phenolic or melamine. Because of the flexibility of molding, these panels can support more complex structures of electronic circuits.

Holes molded into the base have an hour-glass shape as shown in Fig. 3-3. After soldering, the solder nugget secures the component leads in the holes without lead crimping. Conductors lie in 0.016"-deep molded channels that have sloping sides. This recessing of the wiring prevents any component case from touching the conductors and thus shorting. The circuit, including the holes, consists of copper plated with solder. A baked-on solder flux eliminates the need for cleaning up after soldering. Peel strength, increased by the channels and the plate holes, exceeds that of other methods.

The resin presently used in molding is electrical-grade phenol resin with these characteristics: (1) Power factor (1 mc.), 0.025; (2) dielectric constant (1 mc.), 4.4; (3) tensile strength, 7500 psi; (4) flexural strength, 10,000 psi; (5) compressive strength, 32,000 psi; (6) dielectric strength, 380 volts/mil.

* Die-Form Circuits, Inc., Chicago, Ill.

The maximum present panel size is 10" x 6½"; thickness is 0.094".

Conductors

Two materials commonly used as conductors for printed circuits are copper and silver. Other metals used in special cases for abrasion resistance, corrosion resistance, etc., include tin, steel, aluminum, brass, and various alloys.

COPPER

A special electrolytic grade of copper foil 99.5% pure is used for printed circuits because of its low cost, availability, low resistance, and good soldering qualities. This copper foil is available in thicknesses from 0.0007" (0.5 ounce per square foot) to 0.0094" (7 ounces per square foot). Intermediate values may be seen in Table 3-4. Common thicknesses are 0.00135" (one ounce per square foot) and 0.0027" (2 ounces per square foot). This copper is available in a grade of greater than 99% purity developed specifically for printed-circuit use.

Table 3-5 gives resistance values in ohms per inch at 20°C (64°F) for the two most common thicknesses for widths from 1/64" to 1/4".

Current capacity is related to resistance. Because conductors are bonded to the base, the current capacity is related to characteristics of the board, including the effects of heating the bond. The current capacity may be defined as "the maximum current which may be carried by a conductor without resulting in deterioration of either the mechanical or electrical characteristics of the printed board." Fig. 3-4 indicates the amount of allowable direct current, for a board 1/16" thick, as a function of temperature.

SILVER

Silver conductors are generally 0.001" to 0.004" thick. Table 3-6 shows general practice for the silver conductor process.

As there is no adhesive between the conductors and the base in this case*, the current capacity is limited by an allowable temperature rise of 40 C°: For example, starting from 25° C as room temperature with a 40 C° rise, the final temperature would be 65°C. From Fig. 3-5 the allowable direct current for a conductor 0.030" wide and 0.0015" thick is greater than two amperes. At three hundred volts this would be a 600-watt rating—more than required for many applications in communications.

Fabrication

A knowledge of some of the problems of fabrication helps the engineer recognize where small modifications in design can reduce costs without changing the utility of the circuit.

Piercing and blanking dies make the component mounting holes. Holes of unusual shapes and sizes increase the cost of the die. Boards up to ⅛" thick are punched without difficulty. When base thickness exceeds this value, a more expensive method must be used for producing holes.

Usually hole diameter is not smaller than the thickness of the base material. The technique used for mounting the components also affects hole size. Holes should not be too close to the edge of the board—a minimum distance of 1½ to 2 times the thickness of the board is considered normal.

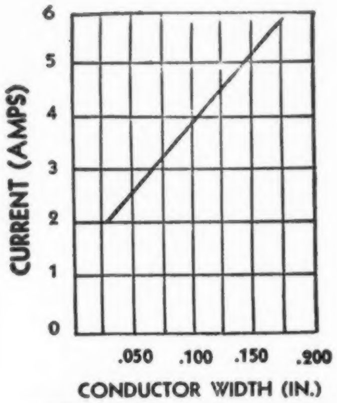
Hole tolerances should be only as tight as actually needed. In most cases the only significant factor is that the component hole allow a good meeting between the wire on the board and the lead wire. It is not necessary to have the lead hole exactly in the center of the printed wire. Component leads require a hole size large enough for insertion without difficulty, but not large enough for excessive play risking a weak connection.

In some cases a small pad, or circular copper area, is provided around a component hole. The normal punching or drilling tolerance should also consider the thermal

* Conductors are die-stamped into the base.

	Range	Recommended for General Practice
CONDUCTOR THICKNESS	0.001"-0.004"	0.0015"
BASE MATERIAL THICKNESS	1/32", 3/64", 1/16" 3/32", 1/8", 1/4"	1/16"
WIDTH OF CONDUCTOR	0.030" min.	0.060"
SPACING OF CONDUCTOR	0.030" min.	0.060"

Table 3-6. Characteristics of the pressed silver process. (Table courtesy Aerovox Corp.)



.0015" thick conductors—on 1/16" thick base material, 40° C rise in temperature.

Fig. 3-5. Current rating of pressed silver conductors. (Drawing courtesy Aerovox Corp.)

Hole Diameter Tolerance in Inches	
PUNCHED (using one die)	DRILLED (using template)
±0.003	+0.003 −0.001
Hole Location Tolerance in Inches for Various Distances	
Up to 2" ±0.005	
Up to 6" ±0.010	
Up to 12" ±0.015	±0.003

Table 3-7. Recommended fabrication tolerances for XXXP boards. (Table courtesy Aerovox Corp.)

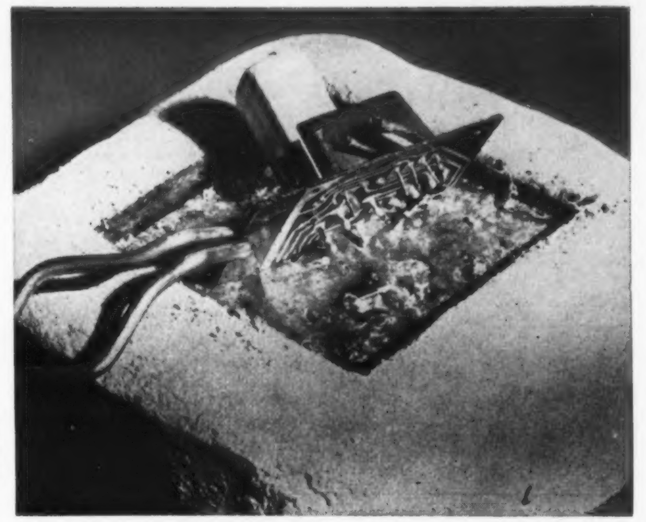


Fig. 3-6. Dip soldering. (Photo courtesy The Formica Co.)

expansion and contraction of the base material which is punched while hot.

Large round holes are least costly because round punches and dies cost less than dies for square, rectangular or other shapes. This is not to say non-circular holes should not be used, for one of the most significant features of the entire printed-circuit process is that holes of almost any size or shape can be used wherever required. But where there is a choice, the relative cost of the die is important.

The spacing between holes is also significant. Spacing kept above 7/32" for commercial punches, or 12/32" for commercial button dies and punches, provides additional cost reductions. Table 3-7 indicates some normal tolerances.

Soldering

The type of flux used with the soldering process depends on the condition of the component leads: For instance, dirty leads require a more active flux. Solder dipping is normally used with printed circuits, although there are several other techniques including brushing or wiping and spraying.

Solder contents depend upon the conductors. For copper, a eutectic solder, 63% tin, 37% lead, which melts at 361° F, is satisfactory. Other solders such as 50/50 or 40/60 (tin to lead) melt at higher temperatures which might damage the board. An original solder containing silver is suggested for silver conductors. This is 63% tin, 35% lead, 2% silver. Repairs can be made on silver with standard 60/40 solder after the initial use of silver-bearing solder in production.

Smaller soldering irons may be used, but care is required to keep the temperature of the conductors below the damage point. A soldering iron with a temperature of about 500°F can cause damage if it is left in place for more than a few seconds. The proper technique is to apply the iron to the component lead and the solder to the conductor on the board.

In manufacturing, after all the components have been placed and their leads crimped where required, the copper-foil face of the board is cleaned and flux applied. Then the entire wiring face of the board is dipped into molten solder (Fig. 3-6). Note that the molten excess solder is falling from the board. This is important—unless great care is used it is possible for the solder to "bridge" between two conductors.

Components exposed to the molten metal for too long a period can fail or suffer changes in their characteristics. At the normal solder bath temperature of between 435°F and 550°F, normal dipping time is between 5 and 10 seconds.

Resistors do not seem to be affected by dip soldering. A small change in their measured value occurs, but usually this is not serious. Capacitors of the plastic, metal, or ceramic types are not damaged by normal dipping, but capacitors which have wax coatings are not dip soldered but are joined with connectors.

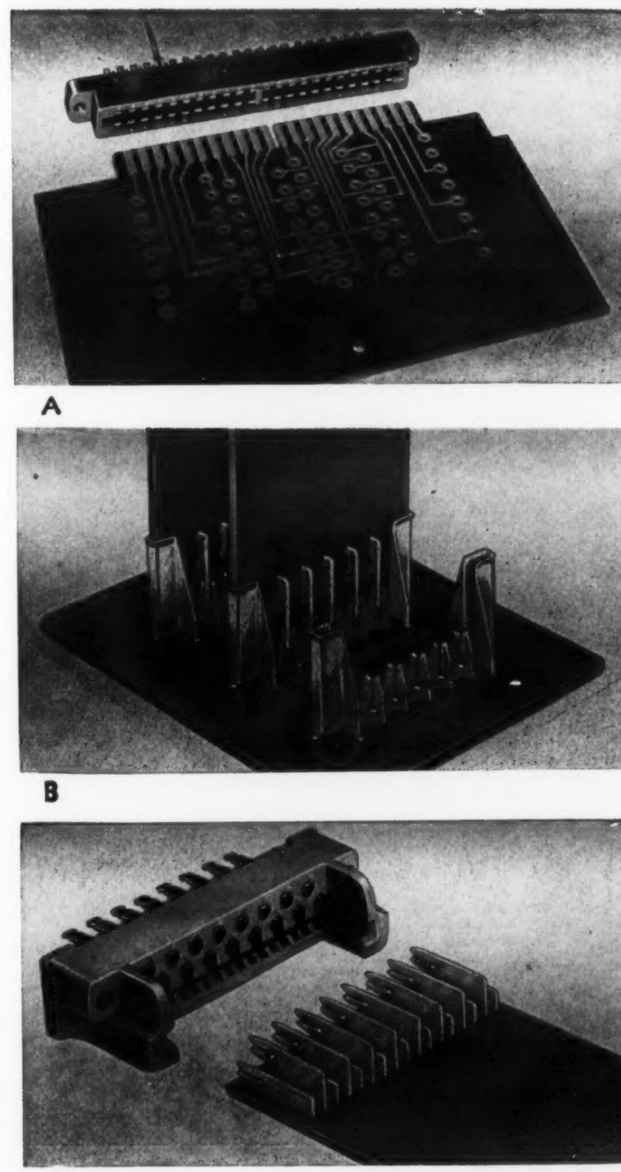
Connectors

Connectors are used (1) between circuits and conventional wiring, (2) between printed boards, as when a small board is mounted on a larger one, and (3) for mounting certain components.

Connectors are a vital part of electronic equipment using several boards as quick removal and replacement of defective boards is a significant aid to repair work.

Usually plug-in circuit packages have printed-wire terminations on the board that fit into a mating female plug on the equipment. These boards have two conflicting objectives; the best possible low-resistance connection is desired, but the connectors must also permit rapid removal of the board. Plug-in board connectors are shown in Fig. 3-7.

Phosphor-bronze silver-plated contacts mounted on 0.2" centers on the board fit into the female receptacle (Fig. 3-7, C.) This connector has a 10-ampere rating at



C

Fig. 3-7. Printed circuit connectors. (Photos courtesy ELCO Corp.)

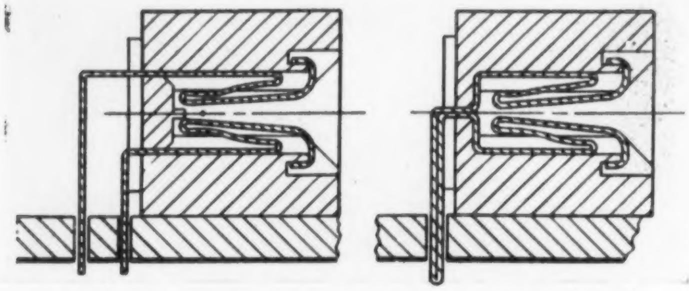


Fig. 3-8. Details of dual (left) and single (right) printed circuit connectors for right-angle mounting. Other variations feature vertical mountings and connections to top of board surface. (Drawings courtesy DeJur-Amsco Corp.)

Fig. 3-9. Micro-Pin sockets for components. (Photo courtesy Techron Corp.)

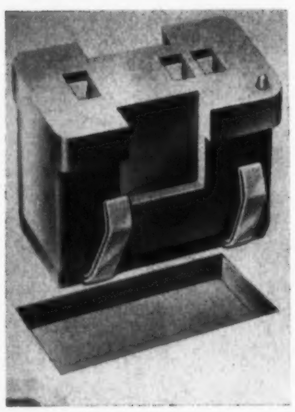


Fig. 3-10. Sub-miniature 3-pin transistor socket for printed circuit. (Photo courtesy ELCO)

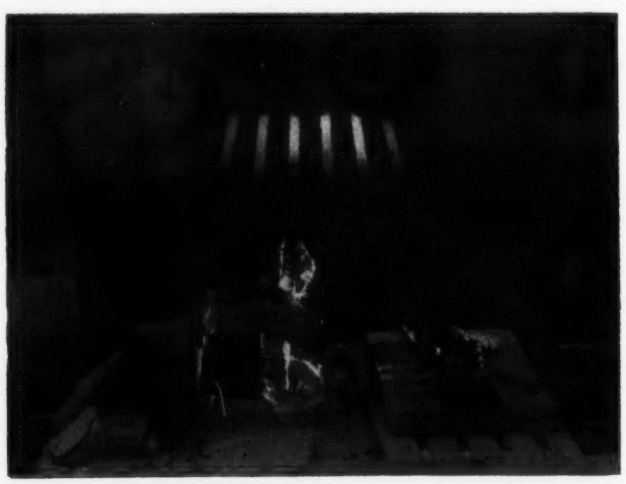


Fig. 3-11. Comparison of an ordinary electronic circuit and high-temperature printed circuit after baking. (Photo courtesy General Electric Research Laboratory)

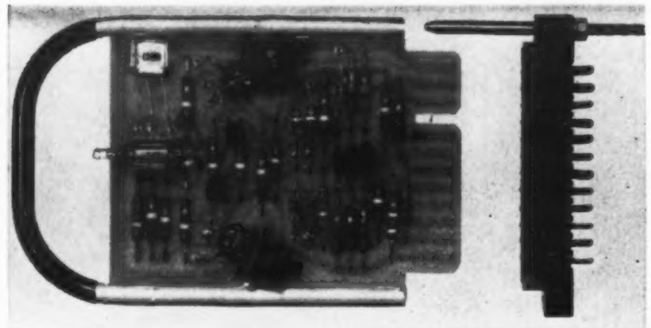


Fig. 3-12. Transistorized 3C-M-PAC flip-flop. (Photo courtesy Computer Control Co., Inc.)

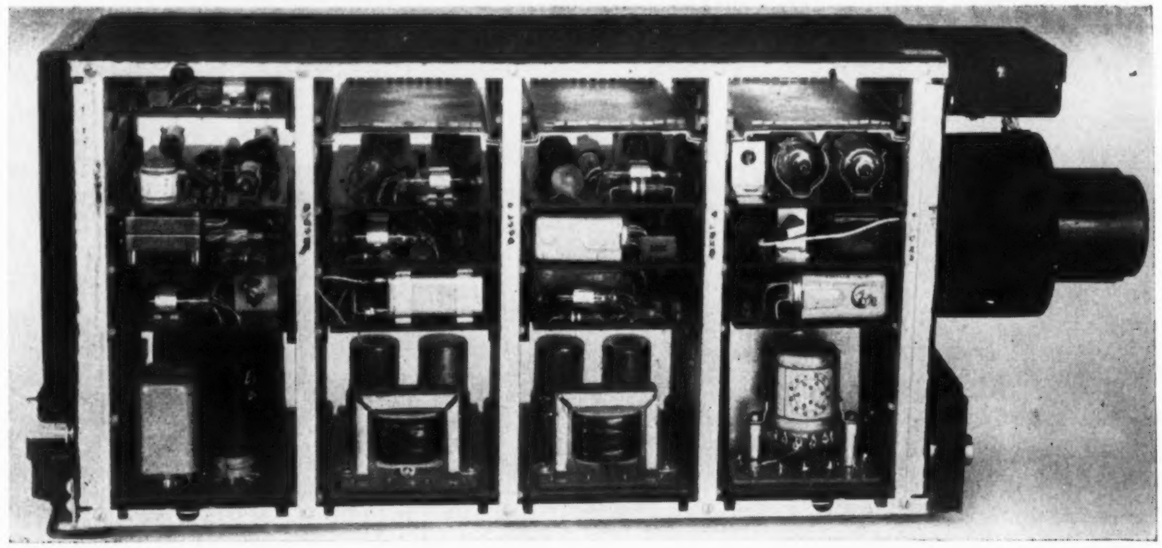


Fig. 3-13. Modular packaging for an airborne application. (Photo courtesy RCA)

3500 volts rms, a contact resistance of 0.002 ohms, and a dry insulation resistance of 25,000 megohms.

A "bellows contacts"* type of connector which maintains a spring-like contact over a wide range of board thicknesses is shown in Fig. 3-8.

Components

Components used in printed circuits will be thoroughly discussed in the next chapter. At this time we will explore only the relation the choice of component has on circuit design.

In most applications, holes are provided in the boards for the component leads. The choice of components, including their physical size and method of mounting as well as their electrical ratings must be determined as early as the first circuit bread-boards. The printed-wiring drawing cannot be completed until the proper size and placing of components has been decided upon. Some components cannot be mounted in holes through the board because they can be damaged in dip soldering. In such cases a solderless friction-grip plug-in socket can be used (Fig. 3-9).

Transistors are becoming more and more important as circuit elements. Because of their very long life there is an increasing trend toward considering them as a fixed and permanent part of the circuit just as a resistor or a capacitor. Often they are placed in the circuit with sockets (Fig. 3-10) to avoid having their characteristics altered during dip soldering.

* Pat. pending, Continental Connectors, DeJur-Amsco

High-Temperature Circuits

One of the limitations of ordinary printed wiring is its maximum operating temperature. New techniques and materials are now able to raise this temperature limit. Fig. 3-11 compares an experimental circuit, with resistors, capacitors, vacuum tubes and printed wiring operated at 1500°F for thousands of hours, to an ordinary circuit after both were removed from the oven in the background.

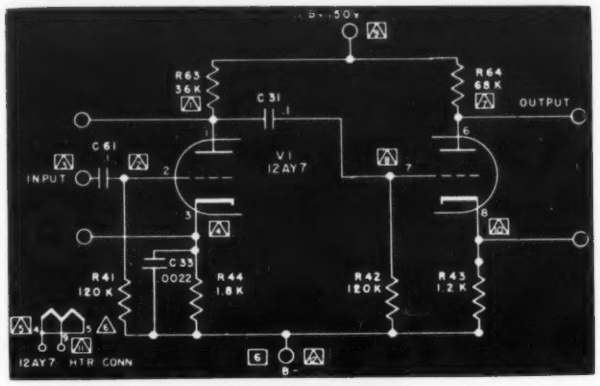
The resistors are hollow evacuated Fosterite ceramic tubes with a resistive coating on the inner surfaces. Titanium end-caps make connections to the circuit.

Capacitors using pure single-crystal alumina (synthetic sapphire) as dielectric have been made. Mica, which ordinarily crumbles at 500-600°C (about 1000°F) has also had its upper temperature limit extended by special heat treatment.

Circuit boards are ceramic with metallic silver conductors. Platinum wires imbedded in the base are joined to the components they support by spot-welding. Ceramic vacuum tubes operate without heaters as at this temperature emission from the cathode is more than sufficient without additional heat. When operation at lower environmental temperatures is also required, the tubes are enclosed in an oven to maintain their operating temperature.

High-temperature printed circuits have important uses in guided missiles and other military electronic equipment where high ambient temperatures are encountered because of component crowding or special operating conditions. The design characteristics of all these materials

A



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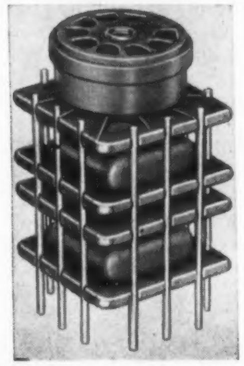
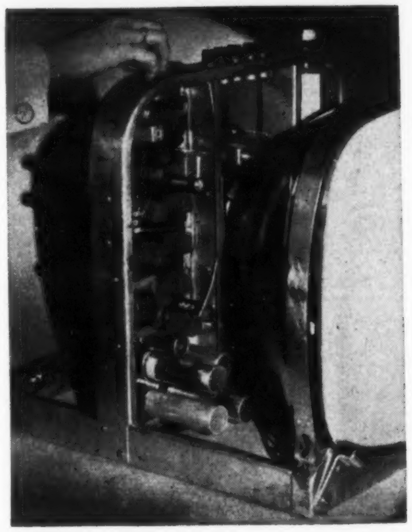


Fig. 3-14. A1001 linear amplifier schematic (A) and assembled module (B). Open squares in schematic denote bottom connection; square with inverted V denotes top and bottom connection. (Drawings courtesy Aerovox Corp.)



A

B

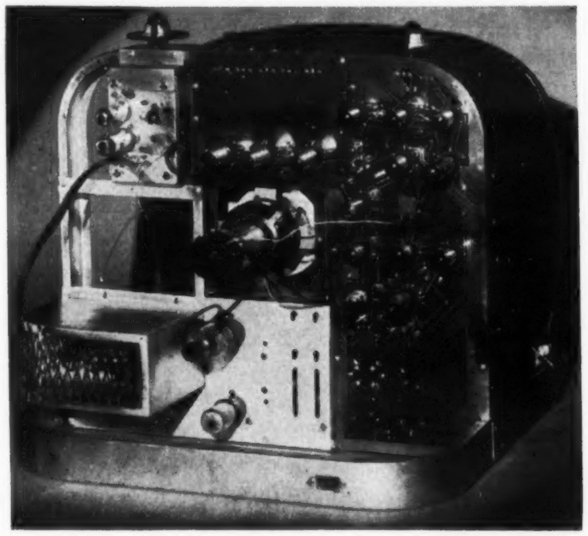


Fig. 3-15. Composite television receiver. A shows modules, B is rear view showing printed board. (Photo courtesy ACF Electronics)

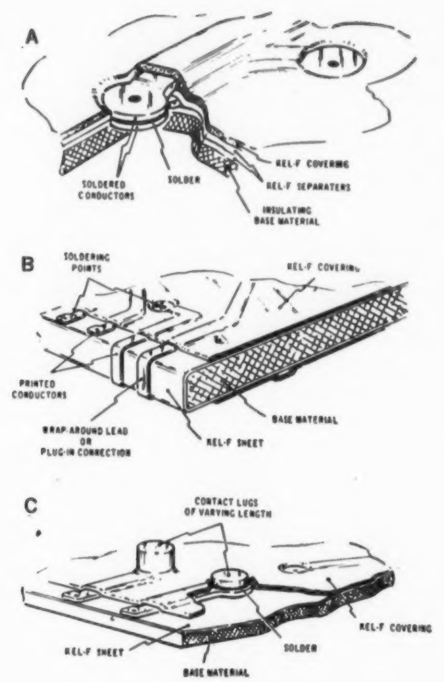


Fig. 3-16. Covered printed circuits. A shows wiring stacked and encapsulated; B shows exposed and wrap-around terminals; C shows molded lugs and terminals. (Drawings courtesy Sanders Associates, Inc.)

at the elevated temperature are greatly changed from their characteristics at room temperature.

Fotoform* glass is a special type of glass which can be used for printed-circuit boards by photo-exposing and etching. It has a dielectric constant of 6.5 (at 1 mc) with zero moisture adsorption, high resistivity and excellent stability up to 500°C.

Modularization

A circuit such as an audio amplifier, cathode follower, or a pulse-generator can be built on a single board (Fig. 3-12). Such use of printed circuits implies an additional step. In any given line of electronic equipment, a circuit can be found more than once. Some, as the examples above, will occur many times. If the proper evaluation is made, a standard circuit can be found which will answer the needs for many equipments. Thus, the basic module is born—a standard circuit which can be used in many equipments.

Modular construction has a two-edged advantage. Standard modules can be produced as end-items and then stored until final assembly. Also standard circuits allow engineering effort to be directed toward developing the best possible circuits, rather than to be divided among a number of circuits which differ only in details.

Circuit packaging and modular construction are interdependent; one cannot very well be changed without considering the other (Fig. 3-13). Circuit modules also can be considered as the starting point from which smaller units are developed. For example, several resistors and capacitors can make up a package which is used very often in modular circuits—indeed in almost all circuits. If a package is made up of these several components, it can be used frequently in different circuits. This is the concept of the "super-component"—the group of individual components mounted as a unit and treated as a unit in purchasing, manufacturing, and servicing the completed equipment. The printed-circuit module could contain several super-components or components packages.

Modules based upon the National Bureau of Standards study of standard circuits are now available from two firms* for rapid circuit building. These units have wide application and are an indication of the use of modular construction.

Fig. 3-14 shows a general-purpose R-C-coupled amplifier with a gain of 40 db at 0.1 v (rms) input. The frequency response variance from 30 cps to 100 kc lies within 1 db. As shown in the legend, the top and bottom connections may be identified from the schematic.

Applications of this modular construction include audio amplifiers, decade counters, if amplifiers, video amplifiers and television receivers in addition to the original Tinkertoy production. A television receiver, designed and constructed to demonstrate the feasibility of such modular construction is shown in Fig. 3-15. This is one large printed-wiring board on which 17 Compac** modules are mounted through square holes. Wires from the modules meet the printed wiring just as with the other components. There are 195 components (plus the tuner) on this receiver. Of this number, 153 are a part of the 17 modules or an average of nine components per module. The 42 components not a part of the modules are such items as power transformers, large resistors or capacitors, and parts which require tuning.

Construction of this type is well adapted to completely mechanized assembly. Manufacturers can purchase such modules to fit the needs of their equipment.

Covered Circuits

One company* has developed a method of producing the printed circuit with a plastic coating** which provides added protection and strength. As shown in Fig. 3-16 several layers of printed wires can be used one on top of the other with interconnections. This provides a greater flexibility in the layout. This "sandwich" method allows for direct paths, which are imperative in UHF and microwave circuits.

The printed wiring can be wrapped around the edge of the board as shown in Fig. 3-16, B, permitting connections from one side of the board to the other. This is done by applying the copper wiring to a thin plastic sheet which is then bonded to the base material. If desired, one end of the wrapped wiring can be exposed and used as the plug-in connection.

* Corning Glass Works

* ACF Electronics, Aerovox
** ACF Electronics

* Sanders Associates
** Kel-F, a fluorocarbon plastic, M. W. Kellogg Company

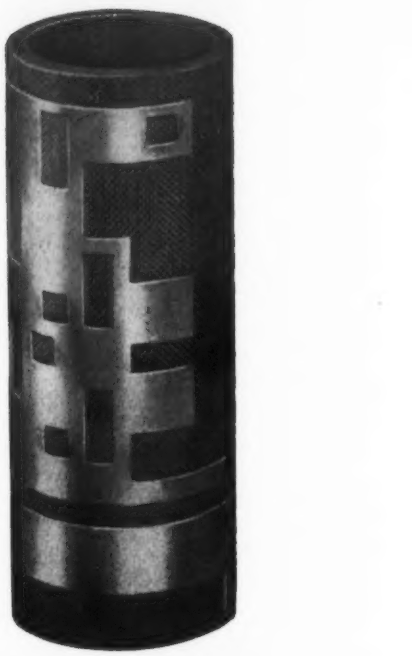


Fig. 3-17. Shaped copper foil. (Photo courtesy Photocircuits Corp.)

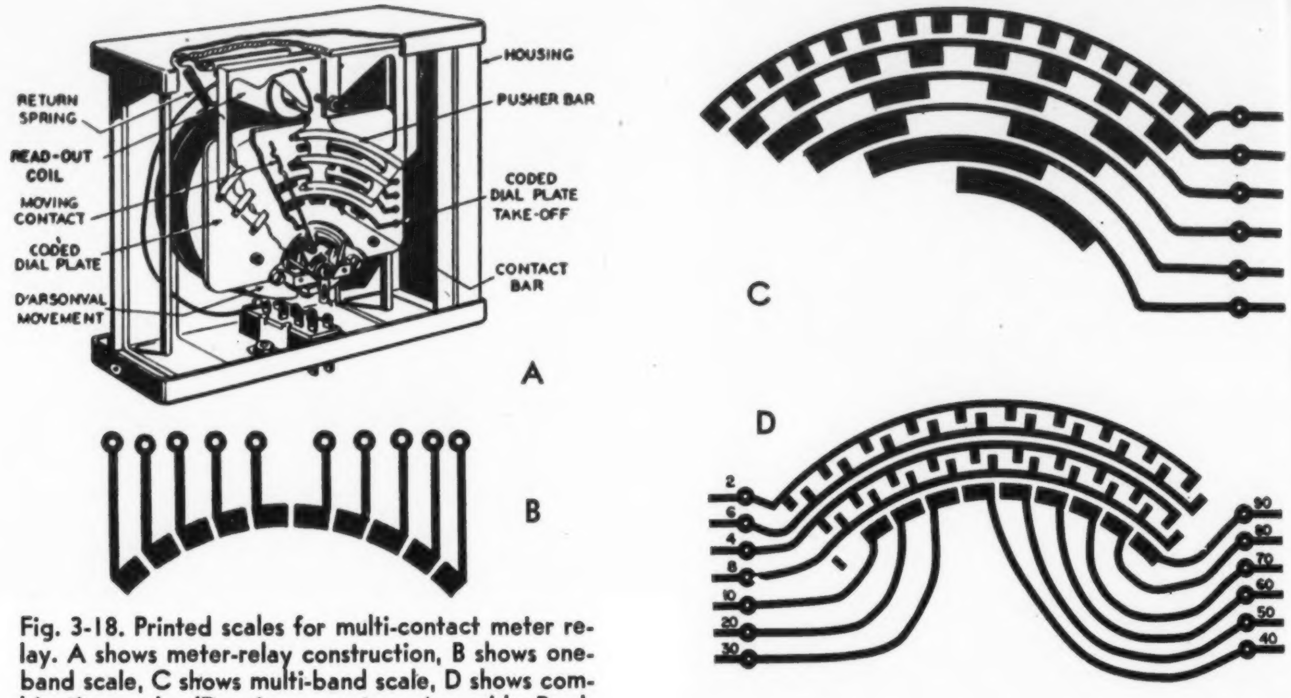


Fig. 3-18. Printed scales for multi-contact meter relay. A shows meter-relay construction, B shows one-band scale, C shows multi-band scale, D shows combination scale. (Drawings courtesy Assembly Products, Inc.)

When wiring is printed on the thin plastic sheet and bonded to the base, it is possible to mold small contacts at the same time. This is indicated in part C of Fig. 3-16. Contacts of different length and size provide various means for connections to the printed circuit.

Other Types

One can almost say that any electrical equipment has a potential application for printed wiring. Among the varied uses are industrial controls, heating pads, area heaters, and automobile dashboards. All of these are under active investigation and in at least pilot production by several manufacturers. One variation of printed circuits is to use a thin flexible insulating base so that the final product can be folded to fit into a case. Transformers have been made using a flat series of coils which are then folded into place on the core. Cylindrical shapes (Fig. 3-17) are being used to save space in certain airborne military electronics.

In England, a compact package of equipment has been produced by printing a long flat circuit and attaching the required components. The printed-circuit is then folded to fit into its case. When repairs are needed the circuit is unfolded. This technique requires special design and care in layout to avoid hot spots in operation or damage during folding.

One of the newest uses of printed wiring is in this multi-contact meter-relay (Fig. 3-18). This meter has a D'Arsonval movement with printed wiring replacing the meter scale. There are contacts on the pointer to complete the circuit through the printed scale. There are two types of scales; in one type the scale is divided into segments along a single band. Ten segments are standard (maximum is 30) and a light or relay is required for each segment. In the second type of scale there are several bands (maximum of 6) and a light or relay is required for each scale. This multi-band scale produces a modified binary output thus functioning as a simple analog-to-digital converter.

When the read-out coil is energized, it pulls the pusher bar and contacting pointer to the printed scale. The coil can be operated automatically or manually. Two readings a second is the fastest current rate of operation.

Make Your Own

Many engineers will want to experiment with their own printed circuits. A pencil line made by an ordinary graphite pencil, the common "lead pencil", will produce a high-value gridleak resistance in an audio amplifier circuit. An ordinary pencil line, about one inch long and drawn on an insulating surface will measure about a megohm. A thick pencil line, the same length and about 1/8" wide, will measure about 300,000 to 400,000 ohms.

It is not possible to save time by using your own printed circuits, for their preparation requires more time than conventional wiring. But the knowledge to be gained is valuable in understanding commercial printed circuits. Several simple techniques are discussed below.

PAINTED CONDUCTORS

A silver paint can be used to paint lines on a plastic base such as a phenolic board. Circuit layout should be as direct as possible. If cross-overs are avoided, production will be simplified. Resistive paints are available and can be used to paint resistors just as the wires are painted. Experimentation is required for painted resistors because the resistance values depend on the length and thickness of the paint.

PUNCHED WIRING

A thin sheet of brass (between 0.001" and 0.003" thick) is first bonded to a plastic base with adhesive. For experimentation almost any type of plastic dielectric material will do. Both surfaces must be cleaned before bonding and the type of glue depends somewhat on the plastic base which is used.

After the circuit is laid out on paper, it is transferred to the brass. The sections of excess brass are removed by cutting with a sharp knife. When the extra glue is removed and the holes are drilled, the circuit is complete.

SUBTRACTIVE ELECTROLYTIC FORMING

One near-commercial method is to take ordinary paint and brush-in those areas where metal is desired in the final circuit. If several boards are desired, a stencil will be convenient. A bath is made from water with a small amount of sulfuric acid carefully *added to the water.* Using the brass plate as the anode, and any other metal as the cathode, place about 6 volts across the circuit. If a large enough sheet of metal is used for the cathode, a reasonably uniform removal of brass will take place. During the cleaning, any remaining glue and paint should be removed.

ADDITIVE ELECTROFORMING

The desired circuit can be painted on a plastic base surface with a conductive paint. In some cases, a soft graphite-lead (ordinary) pencil will serve the purpose. In a plating solution of copper-sulphate, a copper plate is used for the anode and the circuit board is the cathode. Electrical connections must be made to every line of the circuit to be coated. Light lines, easily removed later, may be used to make the circuit one complete electrical

Fig. 3-19. Printed-circuit kits. (Top photo courtesy Techniques, Inc.; bottom photo courtesy Photocircuits Corp.)

path. A low voltage, about 1 to 1½ volts, is used and a heated solution will produce better copper plating. For experimental work such as this, the plating is continued until a thickness of about 0.005″ is obtained, although thinner platings are used commercially. Some companies have made these and other experimental methods available in kit form (Fig. 3-19) for use in preliminary circuit development.

References

The references listed below are representative of sources for materials for printed circuits.

Copper-clad sheets

Mica Insulator Co., 797 Broadway, Schenectady 1, N. Y.; Continental Diamond Fibre Co., Newark, Del.; Formica Corp., Cincinnati 32, Ohio. General Electric Laminated Products Dept., Coshocton, Ohio, Westinghouse Electric Corp., Micarta Div., Hampton, S. Carolina.

Conductive paints

General Cement Mfg. Co., 919 Taylor Ave., Rockford, Ill.; Micro-Circuits Co., New Buffalo, Mich.; Handy and Hardman, 82 Fulton St., New York, N. Y.

Resistance paints

Interelectronics Corp., 2432 Grand Concourse, New York, N. Y.; Micro-Circuits Co., New Buffalo, Mich.

Connectors

U. S. Components, Inc., 454 E. 148 St., New York, N. Y.; Winchester Electronics Inc., Willard Rd., Norwalk, Conn.; Continental Connector Corp., 3030 Northern Blvd., Long Island City, N. Y.; Viking Electric, 21341 Roscoe, Canoga Park, Calif.; ELCO Corp., M St. below Erie Ave., Phila. 24, Pa.

Kits

Tele-Diagnosis Co., 155 W. 72nd St., New York 23, N. Y.; Techniques Inc., 135 Belmont St., Englewood, N. J.; Consultants for Industry, 273 E. 175 St., New York, N. Y.; Harcon Electronikits, Brandywine, Md.; Photocircuits Corp., New St, Glen Cove, N. Y.

Following chapters include:

- Components (*in next issue*)
- UHF Applications
- Circuitry, including packages
- Production, including automation
- Servicing

Fig. 1. Map shows position of master station at N. Carolina beach, slave 1 at Carrabelle, Fla., slave 2 at Forestport, N. Y., and representation of fix lines.

Fig. 2. Estimated and observed CYTAC fix errors in the service area.

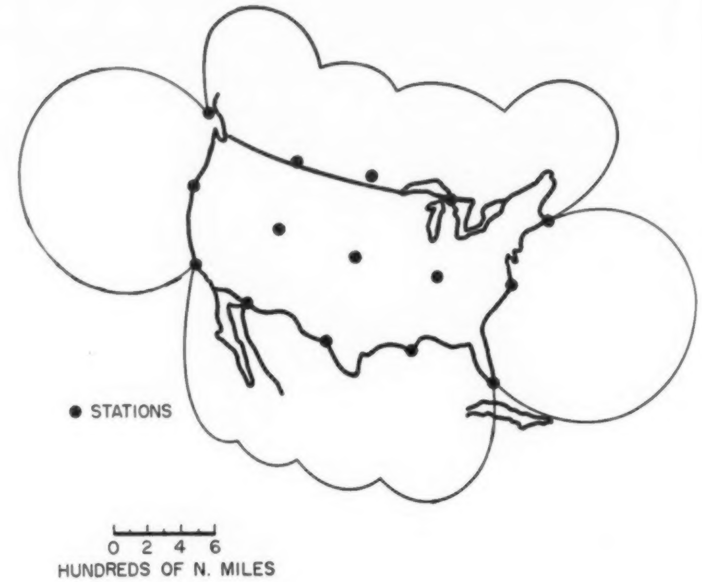


Fig. 3. Fifteen stations, arranged in squares, can provide a continuous all-weather air and sea navigation umbrella over entire U. S. and adjacent sea lanes.

PRECISION MULTI-PURPOSE RADIO NAVIGATION

WILBERT P. FRANTZ
WALTER N. DEAN
ROBERT L. FRANK

Microwave-Electronics Division
Sperry Gyroscope Company

MODERN high-speed air and marine transportation needs a precise long-range navigation system. CYTAC is one system, suitable for terminal area and enroute control of aircraft, that can provide high-accuracy positional data for both air and marine use. The system was developed and field tested under a contract with Rome Air Development Center and Wright Air Development Center of the Air Force. It is manufactured by Sperry Gyroscope Co.

The principle used is essentially an extension of the principles of Loran, which is in use in the Atlantic and Pacific as a long-range aid to marine navigation. In operation, *master* station (Fig. 1) transmits pulses of radio frequency at a uniform repetition rate. Two *slave* stations transmit similar pulses and synchronize their transmission with the masters. A receiver in the service area measures the time differences between arrival of the master pulse and each of the slave's pulses, and obtains a positional fix at the crossing of the appropriate lines of position. Synchronization at both slaves and at the receiver is by ground wave only.

The CYTAC system differs from standard Loran in three major ways: First, CYTAC achieves longer range, particularly over land, by using low-frequency transmission within the internationally allocated band 90 to 110 kc, compared with the band just below 2 mc for standard Loran. Second, higher precision is obtained by comparing the phase of the r-f cycles within the received pulses relative to those within the master signal; the instrumental accuracy of CYTAC is approximately 0.2 to 0.3% of the period of the radio frequency, or 20 to 30 milliμsecs. Third, CYTAC instrumentation is automatic in operation, which eliminates inaccuracies due to personnel error.

CYTAC also differs from the low-frequency Loran system tested ten years ago. First, sufficiently sharp rising pulses achieve a pulse-envelope time measurement of sufficient accuracy to resolve ambiguities of r-f cycle phase measurement and to achieve separation of ground and skywave to permit measurement on a single signal component. Second, a lower frequency (100 kc compared to 180 kc) is employed, which greatly improves over-land coverage. Third, the automatic instrumentation incorporates advanced detection, filtering and measuring techniques.

At any considerable distance, the displacement for a given error varies directly with distance, and inversely with the length of the baseline. From this expression, the advantage of long base lines for a system becomes apparent. As long as the ratio of distance to baseline is small, the accuracy is high and relatively constant.

Constant accuracy contours for a typical hyperbolic triad are shown in Fig. 2. A fourth station, providing area coverage, can be added to form a "star chain", or a square. The square configuration provides the best geographic fix for a given timing error within the square. If the coverage area within the square is large, the baselines will be long compared with the distances from the receiver to the four transmitting sites.

Proposed Station Configurations

Fig. 3 shows a possible coverage of the United States by means of fifteen stations arranged in squares. It provides high-accuracy area coverage with a long-baseline hyperbolic system. The ranges are modest compared with the ranges obtained in the field evaluation tests, providing a substantial safety factor.

Aircraft Receiver

The only equipment which has been built and tested has been experimental and contained classified functions not required for a general-purpose navigation system. The experience with this equipment indicates that a 40- to 50-lb airborne receiver can have instrumental accuracies of a few hundredths of a microsecond. This receiver will automatically search for, and lock on, the signals and automatically present the time-difference-number of pairs of lines of position.

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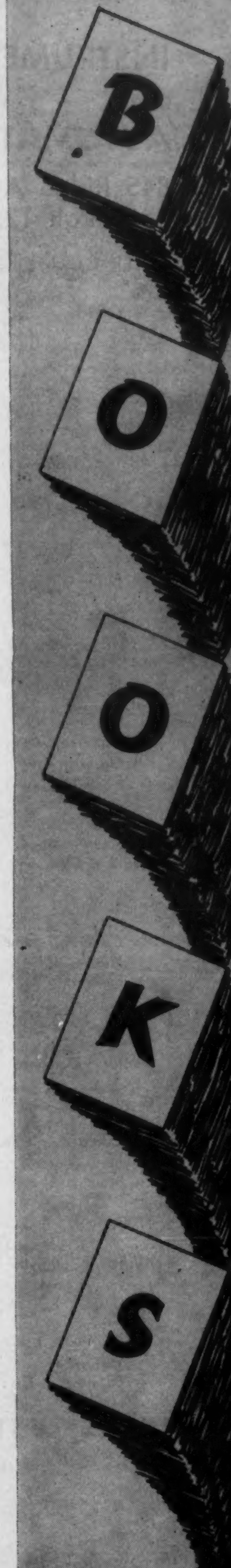

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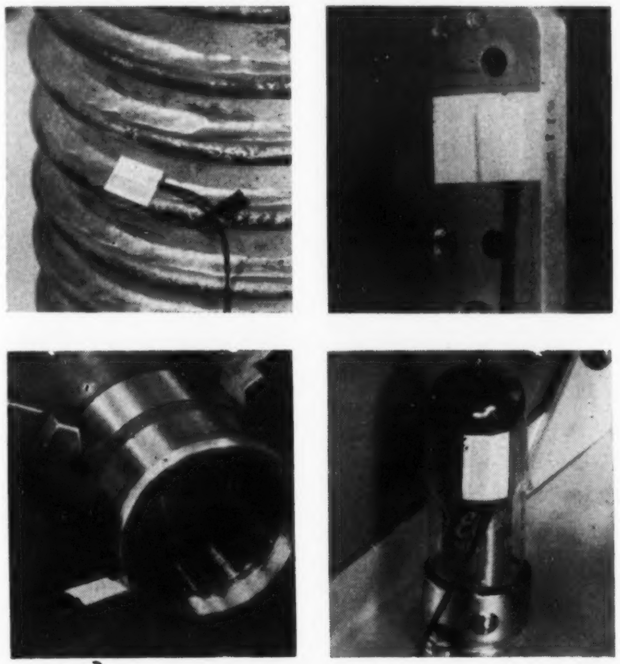

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A series of resistance thermometers is available for use from —300° F to +400° F, each with a 200 F° range and a resistance change of 100 ohms over the 200 F° operating interval. Other resistors are available to operate at temperatures up to 900° F. Interchangeability with other Trans-Sonics temperature transducers is facilitated by their uniform temperature-resistance characteristics.

Maximum continuous current rating is 20 ma, but peak currents of approximately 60 to 70 ma may be used in a commutator circuit where the duty cycle is sufficiently small (conducting 1 part in 36) to prevent overheating.

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Table 9—Characteristics of Electronic Computers

COMPUTER	Mfgr.	Price	Number System	Word Size	Internal Storage	Input	Output
Alwac III-E	Alwac Corp.	$48,000	Binary	32 bits	Mag. drum Mag. tape	Flexowriter Punched card Paper tape Mag. tape	Flexowriter Punched card Paper tape Mag. tape
Alwac 800 system	do	$200,000	Decimal	12 digits	Mag. core Mag. drum Mag. tape	Mag. tape Punched card Paper tape Keyboard Flexowriter	Speed printer Punched cards Paper tape Mag. tape Flexowriter
G-15A	Bendix Aviation	$44,800 $1350/mo. rent	Binary	29 bits	Mag. drum	Typewriter Paper tape Magnetic tape	Typewriter Paper tape Magnetic tape
G-15D	do	$49,500 $1485/mo. rent	Binary	29 bits	Mag. drum	Typewriter Paper tape Magnetic tape Punched card conv.	Typewriter Paper tape Magnetic tape Paper tape punch Punched card conv.
DA-1(DDA)	do	$13,700 $555/mo. rent (+G-15D	Binary	28 bits	Mag. Drum	Graph plotter/follower G-15D input equipment	Graph plotter G-15D output equipment
E-101	Electrodata Div. of Burroughs Corp.	$38,000 $1000/mo. rent	Decimal	12 digits	Mag. drum	Punch tape Accounting Machines	Punched tape Accounting machines
Datatron	do	$135,000 $3900/mo. rent	Decimal	10 digits	Mag. drum	Keyboard Punched Cards Paper tape Magnetic tape	Flexowriter Punched cards Line printer Magnetic tape
LGP-30	Royal McBee Corp.	$39,600 $1100/mo.	Binary	32 bits	Mag. drum	Flexowriter	Flexowriter
IBM 650	International Business Machines	$3750/mo. rent-to $20,000	Decimal	10 digits	Mag. drum Mag. cores Disk storage	IBM cards Mag. tape	IBM cards Printer Mag. tape
IBM 701	do	$17,000/mo. rent	Binary	36 bits or 18 bits	Mag. drum Electrostatic Mag. core	IBM cards Mag. tape	IBM cards Printer Mag. tape 740-CRT 780-Display
IBM 702	do	$25,000/mo. rent	Decimal	Variable	Mag. drum Electrostatic Mag. core	IBM cards Mag. tape	IBM cards Printer Mag. tape
IBM 704	do	$35,000/mo. rent	Binary	36 bits	Mag. core Mag. drum	IBM cards Mag. tape	IBM cards Printer Mag. tape 740-CRT 780-Display
IBM 705	do	$30,000/mo.	Decimal	Same as 702	Mag. core Mag. drum	IBM cards Mag. tape	IBM cards Printer Mag. tape
Univac I	Remington Rand	$25,000/mo.	Binary-coded decimal	12 digits	Acoustic delay line	Cards, Paper tape, Mag. tape	Mag. tape to cards, Paper tape, Printer Typewriter
Univac II	do	$30,000/mo.	Binary-coded decimal	12 digits	Mag. cores	Cards, Paper tape, Typewriter to mag. tape	Mag. tape to cards, Paper tape, Speed printer, Typewriter
Univac Scientific 1103A	do	$32,500/mo.	Binary	36 bits	Mag. cores Mag. drums	Mag. tape Cards Paper tape	Cards Paper tape Mag. tape
Monrobot	Monroe Calc. Mach. Co.	$75,000	Decimal	20 digits	Mag. Drum	Flexowriter	Flexowriter
Readix	J. B. Rea Co.	$98,000	Decimal	10 digits	Mag. drum	Flexowriter Punched tape Mag. tape IBM cards	Flexowriter Punched tape Mag. tape IBM cards Point plotter
Elecom 50	Underwood Corporation	$25,000	Decimal	10 digits	Mag. drum	Accounting machines	Accounting machines

MILTON H. ARONSON
MILITARY AUTOMATION

and

MARTIN L. KLEIN
North American Aviation, Inc.

MODERN DI

MORE than a score of intermediate capacity digital computers are now available commercially as shown in Table 9, and each emphasizes certain features such as flexibility, ease of setup, speed of operation, etc. However, all have the basic components shown in Fig. 23.

Input Equipment

A listing of available input equipments in order of speed of operation is as follows:

1. Keyboard
2. Electric typewriter
3. Punched (Hollerith) cards
4. Perforated tape
5. Magnetic tape

Table 10—Memory Cost (per Bit) vs Access Time

		Cost Per Bit	Access Time, Sec.
1. High-Speed Random Access	Ferrite Cores	$1.00	10^{-6}
	Cathode-Ray Tube	$1.00	10^{-6}
	Vacuum Tubes	$10.00	10^{-6}
2. Medium Access	Magnetic Drums	$0.01	10^{-2}
3. Slow Access	Magnetic Tape	$0.0001	10

In previous issues we learned basic digital codes and techniques. Now let us program five leading medium-size general-purpose computers for a simple arithmetic operation. This is a powerful introduction to general-purpose computation.

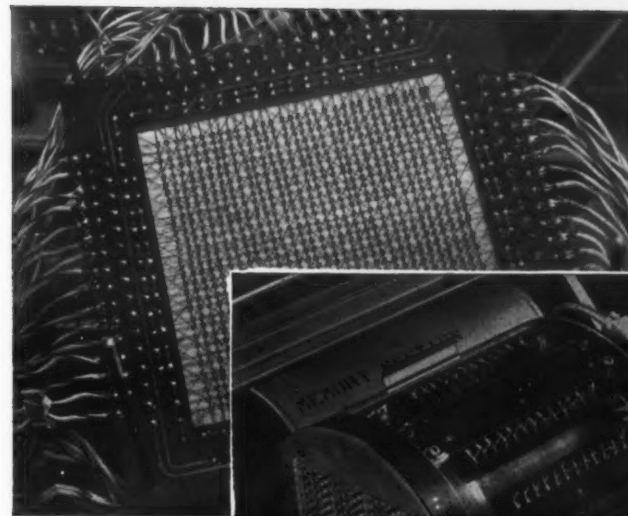


Fig. 25A. UNIVAC core memory unit.

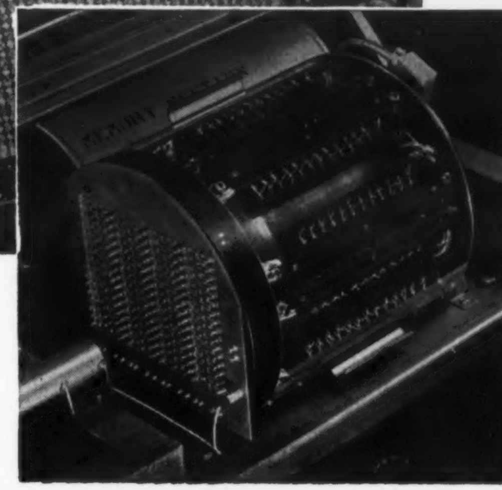


Fig. 25B. LGP-30 magnetic-drum memory has 64 heads, each of which can record 64 words of information.

DIGITAL TECHNIQUES

Some computers are designed for use with only one type of input; others will accept several types.

Memories

The memory is the device that stores the data within the computer, including the input data, intermediate results, output data, etc. The ideal memory would have infinite capacity (number of bits of information) and zero access time (time to reach any one desired bit of information). However, capacity and access time are mutually incompatible—one is gained at the expense of the other. Thus combinations of memories are used—with tape or cards being used where large capacity is required, and drums or storage tubes being used for rapid access to whatever data is needed at the moment. Fig. 24 shows how a tape, a drum, and a high-speed random-access memory can be used with one arithmetic element in a computer. Table 10 gives orders of magnitude of access time and cost. Cost is usually expressed in terms of cost/bit, with 4 to 7 bits being required to represent one decimal digit in a data-processing system.

Fig. 25 shows typical memories, including drums, tape handlers and storage tubes.

Perhaps the latest developments in the field of memory devices are those involving quasi-random access. Here tape is used in ingenious arrangements

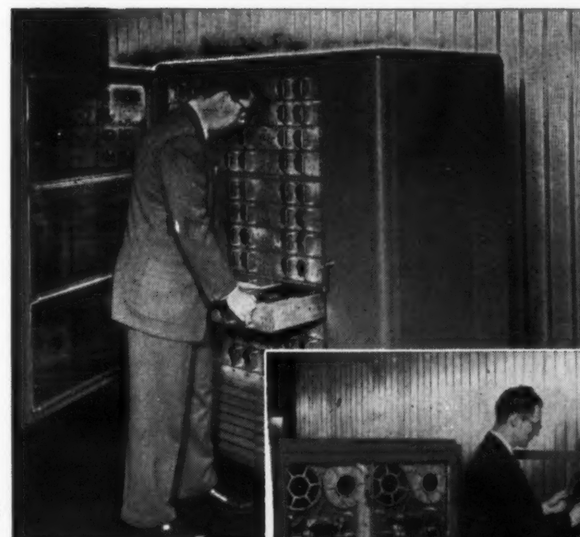


Fig. 25C. Cathode-ray tubes for electrostatic storage in IBM machine.

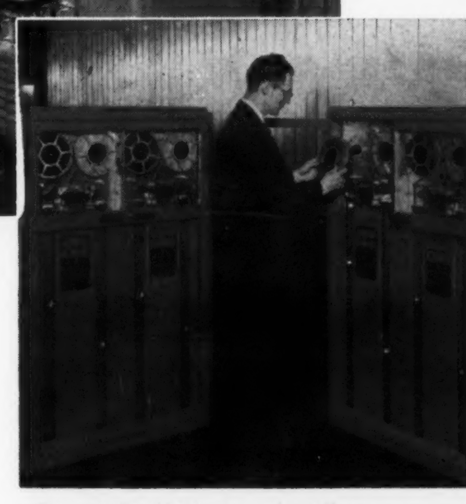


Fig. 25D. IBM tape handlers can introduce or record data at rate of 12,500 digits a second and have a capacity in excess of 2,000,000 digits per tape.

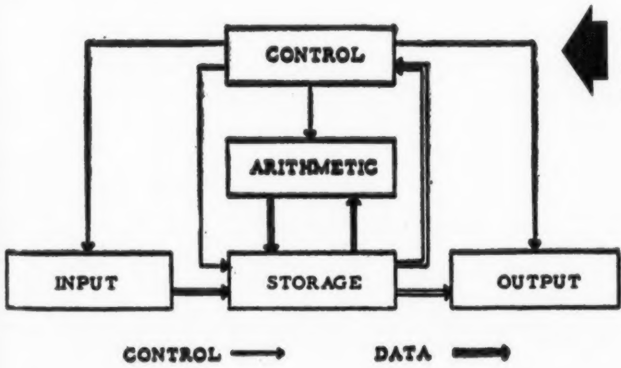


Fig. 23. All digital computers have these basic elements —input-output elements, storage device, arithmetic unit, and control unit.

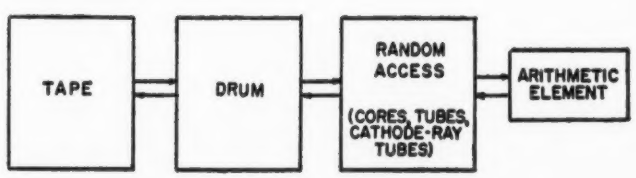


Fig. 24. Use of a combination of memories.

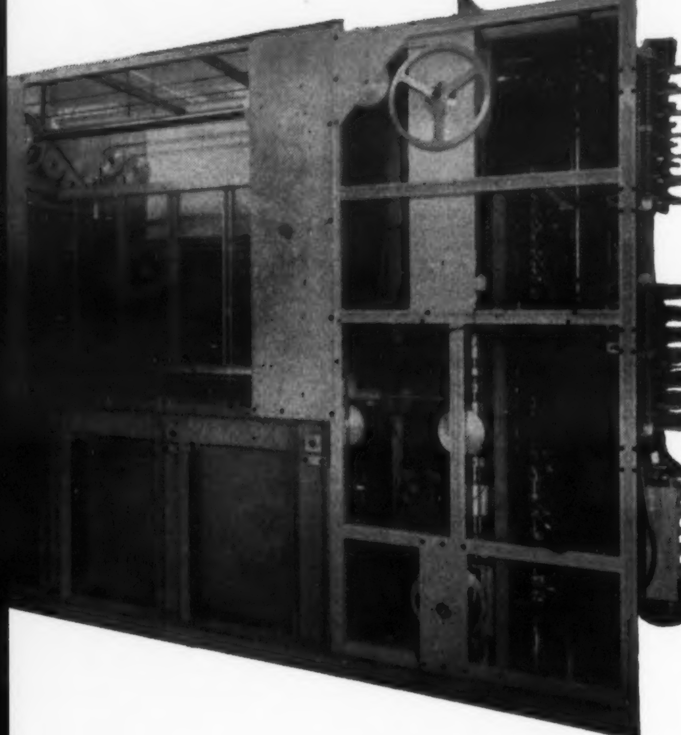


Fig. 26. Front view of RAM with skin removed to show construction features. One page is shown raised into position for reaching the lower-most data location. To extreme right are solenoid-operated valves that direct air pressure to appropriate sides of access cylinders for positioning. The page-selection (x-motion 10-cylinder) system is visible through framework as are the page lifting (z-motion) cylinders. Cylinder motion is transmitted to the access mechanism by means of steel tapes. The storage compartment is pressurized to prevent accumulation of dust on recording surfaces.

Fig. 28. Bendix Model G-15D provides a versatile general-purpose computer in combination with a digital differential analyzer.

so that access can be made to any one spot on the tape much more rapidly than can be achieved by conventional tape handlers. Fig. 26 and 27 show two of these late developments. In the "Tape DRUM," about 200,000 bits can be stored on one "page" (section of tape being scanned by pickup heads located on the rotating drum). Many pages can be used to extend the storage capacity to 100 million bits of information or more.

Fig. 26 shows the new RAM random-access memory device in which 500 million bits can be stored in a relatively small cabinet. Bits are stored on strips of tape, mounted vertically on a frame. By selecting one frame (or "page"), raising it vertically, and positioning the pickup heads horizontally, any one selected bit or word bits can be reached within ½ second average access time.

Programming a Computer

The steps in using a computer are:

1. State the problem.
2. Select the mathematical procedure, perhaps by numerical analysis.
3. Prepare a flow diagram.
4. Write each command in proper code.
5. Assign location for each command and each bit of data.
6. Run program through computer.
7. Debug the program by finding mistakes in each step.

Libraries of programs or parts of programs (subroutines) can be filed for use in similar programs, reducing the preparation and debugging time required.

Operational Instructions

The operational circuitry of the computer performs the desired arithmetic operations. In addition to the basic four arithmetic operations— add, subtract, multiply and divide—the computer can have many other built-in basic instructions.

Table 11 gives sample instruction order lists used for each of five low-priced, general-purpose digital computers; the G-15D (Fig. 28), the LGP-30 (Fig. 35), the Alwac 111-E (Fig. 38), the E101 (Fig. 39) and the Elecom 50 (Fig. 41). Note the key part of the arithmetic unit in most machines is called the accumulator.

G-15D

A cross section of the Bendix Model G-15D magnetic-drum memory (Fig. 29) shows how each

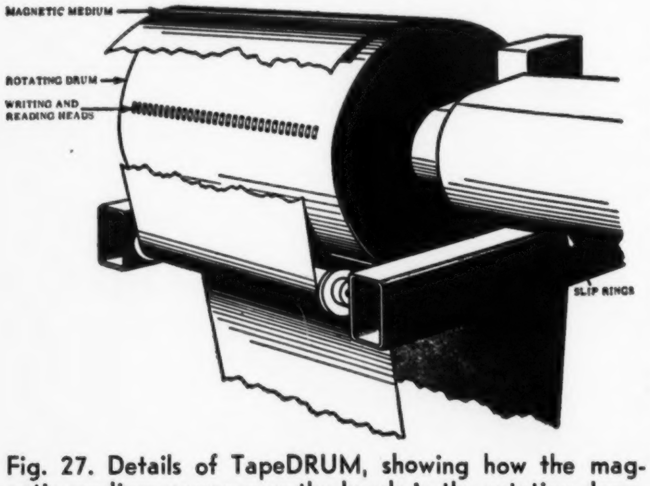
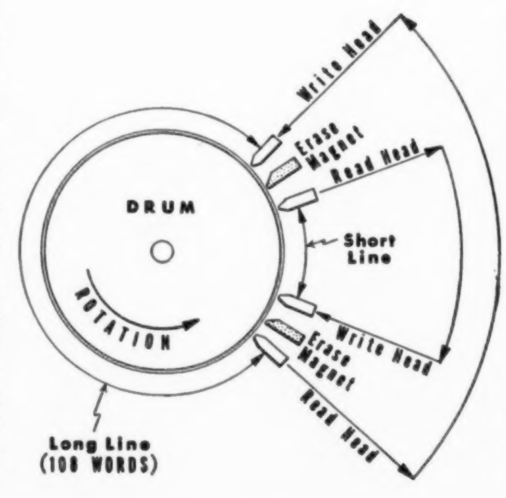


Fig. 27. Details of TapeDRUM, showing how the magnetic medium passes over the heads in the rotating drum.

Fig. 29. Cross section of the G-15 magnetic drum. Each of 20 "long" lines, or circumferential tracks, contains 108 words of 29 bits. Rapid-access storage consists of four "short" 4-word lines; the arithmetic registers are a 1-word line and three 2-word lines. The read and write heads are staggered as shown.



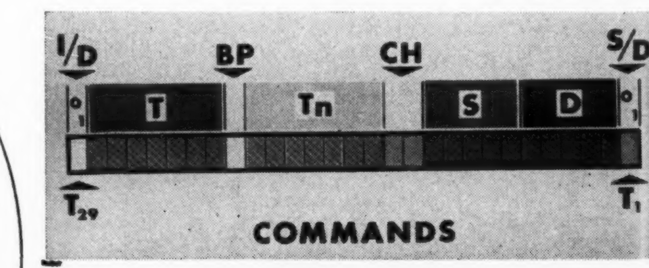


Fig. 30. A 29-bit word designated as a command. The first bit at left (i/d) signifies whether the command is immediate (i) or deferred (d). The next 7 bits (T) specify the time of operation. Tn is the location of the next command; ch is the characteristic operation to be performed; S is the source; D the destination; s/d the precision (single or double). The BP bit indicates a break point.

G-15D

INFORMATION TRANSFER	T or L_k	N	C	S	D
Transfer word between addresses (neither address a two-word register)	T	N	O	S	D
ARITHMETIC OPERATIONS					
Clear and add to AR	T	N	I	S	28
Clear and add absolute value to AR	T	N	2	S	28
Clear and subtract from AR	T	N	3	S	28
Add to AR	T	N	I	S	29
Add absolute value to AR	T	N	2	S	29
Subtract from AR	T	N	3	S	29
Store sum or difference from AR	T	N	I	28	D
Clear multiplication and division registers	L_3	N	O	23	31
COMMAND CHANNEL SELECTION					
Select command line and mark	wT	N	C	21	31
Select command line and return	L_2	L_1	C	20	31
Take next command from AR	L_2	N	O	31	31
SPECIAL COMMANDS					
Halt	L_2	N	O	16	31
Ring bell	L_1	N	O	17	31
REGULAR OUTPUT					
Type line 19	L_2	N	O	09	31
Punch line 19 on tape	L_2	N	O	10	31
Punch line 19 on cards	L_2	N	O	11	31
Type out AR	L_2	N	O	08	31
Write on magnetic tape	L_3	N	C	01	31

E 101

Instruction	Operation
+(78)	ADD contents of memory location (78) to the contents of the accumulator.
−(78)	SUBTRACT contents of memory location (78) from the contents of the accumulator.
×(78)	MULTIPLY contents of memory location (78) by the contents of the B register; answer is left in the accumulator.
÷(78)	DIVIDE the contents of the accumulator by the number in the B register and store the answer in memory location 78.
R(78)	READ the contents of memory location 78 into the accumulator, leaving the number also in 78.
W(78)	WRITE the contents of the accumulator in memory location (78) leaving the number also in the accumulator.
A I (7)	SHIFT LEFT—shift the contents of the accumulator 7 places to the left.
A 2 (7)	SHIFT RIGHT—shift contents of accumulator 7 places to the right.
A 3	ABSOLUTE VALUE—make contents of accumulator positive.
A 4	NEGATIVE OF ABSOLUTE VALUE—make contents of accumulator negative.
A 5	CHANGE SIGN of the number in the accumulator.
A ★	HALT machine.
B	B REGISTER—Transfer contents of accumulator into B register, leaving number also in accumulator.
K	KEYBOARD—Transfer contents of keyboard into accumulator when operator depresses motor bar.
P	PRINT contents of accumulator, leaving copy in accumulator.
U(78)	UNCONDITIONAL TRANSFER—Execute instruction on pinboard 7, step 8.
C(78)	CONDITIONAL TRANSFER—Execute instruction on pinboard 7, step 8, if contents of accumulator are negative; if not, go to next step in program.
S	STEP the internal switch
H	HOME—or advance the internal switch to a give position.
T	TAPE input (data and instructions).
	OTHER instructions are variations of the above.

Table 11—Instruction Order List Showing Code For Each Instruction

LGP-30

	Code	Instruction	Effect
ARITHMETIC	0001	B m*	Bring. Clear the accumulator, and add the contents of location m to it.
	1110	A m	Add contents of m to the contents of the accumulator, and retain the result in the accumulator.
	1111	S m	Subtract the contents of m from the contents of the accumulator, and retain the result in the accumulator.
	0111	M m	Multiply the number in the accumulator by the number in memory location m, terminating the result at 30 binary places.
	0110	N m	Multiply the number in the accumulator by the number in m, retaining the least significant half of the product.
	0101	D m	Divide the number in the accumulator by the number in memory location m, retaining the rounded quotient in the accumulator.
	1001	E m	Extract, or logical product order—i.e., clear the contents of the accumulator to zero in those bit positions occupied by zeros in m.
TRANSFER CONTROL	1010	U m	Transfer control to m unconditionally—i.e. get the next instruction from m.
	1011	T m	Test, or conditional transfer. Transfer control to m only if the number in the accumulator is negative.
RECORD	1100	H m	Hold. Store contents of the accumulator in m, retaining the number in the accumulator.
	1101	C m	Clear. Store contents of the accumulator in m and clear the accumulator.
	0010	Y m	Store only the address part of the word in the accumulator in memory location m, leaving the rest of the word undisturbed in memory.
	0011	R m	Return address. Add "one" to the address held in the counter register (C) and record in the address portion of the instruction in memory location m. The counter register normally holds the address of the next instruction to be executed.
MISC.	0100	I	Input. Fill the accumulator from the Flexowriter.
	1000	P t	Print a Flexowriter symbol. The symbol is denoted by the track number part of the address (x).
	0000	Z t	Stop. Contingent on five switch ($T_1 \ldots T_5$) settings on the control panel.

*The address part of the instruction is denoted by m when it refers to a memory location, by t when only the track number is significant. For example, m might be 4732, meaning sector 32 of track 47.

Alwac III-E

ARITHMETIC

61	Add
67	Subtract
63	Minus add
65	Minus subtract
bd	Long add
bf	Long subtract
e7	Multiply
e5	Multiply by D
e3	Add multiply
e1	Add multiply by D
ef	Divide
ed	Divide by D
eb	Long divide
e9	Long divide by D

ACCUMULATOR

22	Round off
28	Clear A
2c	Absolute value
2e	Reverse A sign
3e	Complement A

INPUT-OUTPUT

f1	Hex. in
f3	Alphabet in
f5	Hex. out
f7	Alphabet out
f9	Sign in
d5	Sign out
dd	Number out

COPY & EXCHANGE

69	Exchange A and W
49	Copy A to W
79	Copy W to A
b5	Copy M to A
30	Exchange A and B
c5	Copy B to W
41	Copy W to B
32	Copy B to A
3a	Exchange A and D
c7	Copy D to W
5b	Copy W to D
38	Copy D to A
36	Exchange A and E
c3	Copy E to W
57	Copy W to E
34	Copy E to A
4d	Copy address to W
4f	Copy half to W
6d	Copy Address to A
6f	Copy half to A
71	Extract (D)
75	Extract

JUMP & RELATED

11	Jump
13	Control jump 1
15	Control jump 2
17	Count down
19	Non-zero jump
1b	Stop

Elecom '50'

CODE	DESCRIPTION	SYMBOLIC DESCRIPTION
None	Clear the contents of the listed registers so that they contain zero after the operation.	$(Ri) = O$; $(WI) = (WI)_o$
ACDE	Clear the accumulator and the listed registers to zero then enter the contents of the keyboard into the accumulator and from the accumulator into the listed registers.	$(WI) = (K)_o$; $(Ri) = (K)_o$
AEI	Same as AE except that the entry is not from the the keyboard but one word from paper tape.	
AEO	Same as AE except that one word is punched out on paper tape.	
BE	Clear the accumulator to zero and then add the contents of the listed registers into it.	$(WI) = \Sigma (Ri)_o$; $(Ri) = (Ri)_o$
BC	Subtract the contents of the listed registers from the contents of the accumulator.	$(WI) = (WI)_o - \Sigma(RI)_o$; $(Ri) = (Ri)_o$
AB	Multiply the contents of the accumulator by the contents of the listed register without roundoff. The result is left in the accumulator.	$(WI) = (WI)_o \times (Rk)$ unrounded; $(Rk) = (Rk)_o$
ABE	Same as AB but with roundoff.	$(WI) = (WI)_o \times (Rk)$ rounded; $(Rk) = (Rk)_o$
W	Print out on main carriage according to sectors set up.	

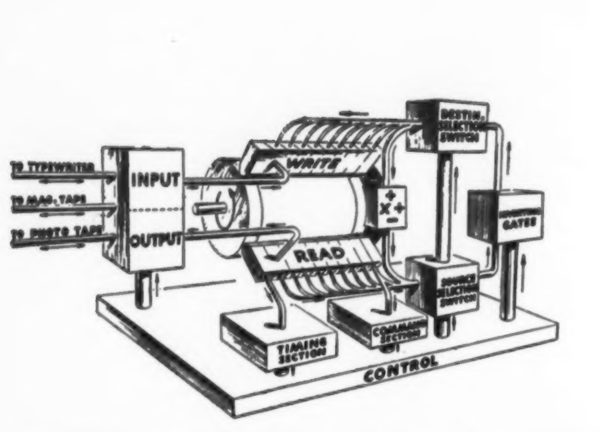


Fig. 31. Schematic representation of the major functional components and paths of information flow in the G-15.

NOTES	LOCATION	OPER. CODE	ADDRESS	k
Clear the accumulator and enter the number 14 stored in address 500	0	4v	500	0
Add the number 328 stored in address 501 to the accumulator	1	5v	501	0
Type out the accumulator	2	20	000	0
Halt computation	3	42	000	0

Fig. 32. Addition of 14 and 328 using Intercom system. Here conversion for decimal typein and typeout is automatic, rather than called for in the program. Accommodation for floating point number system is also built into the routine, eliminating the scaling requirements of standard programming methods.

Table 12

Representative Intercom 101 Orders

Group I —ARITHMETIC OPERATIONS—Operations involving a memory position and the A register

- 49 Clear and Subtract
- 4v Clear and Add
- 4z Divide
- 59 Subtract
- 5v Add
- 5x Store
- 67 Multiply

Group II —TRANSFERS OF CONTROL OPERATIONS

- 0v Transfer if A Register is negative
- 10 Transfer if A Register is non-negative
- 19 Unconditional Transfer
- 42 Halt

Group IV—OUTPUT OPERATIONS

- 1z Type and Tab
- 20 Type and Carriage Return
- 21 Stack
- 22 Type the Stack

of 20 long lines contains 108 words of 29 bits each; each short line contains 4 words. Each instruction or command (Fig. 30) is a 29-bit word. A schematic of the machine (Fig. 31) shows relationships between functional components.

A number of flexible programming methods enable both the beginner and the expert to use the G-15D effectively. These various methods are as follows:

1. Simplified programming with the Intercom interpretive and compiling system.
2. Machine language programming with a standard set of commands.
3. Advanced programming, permitting modification of the standard commands, in order to perform additional functions and to achieve minimum access coding.
4. Micro-coding techniques that enable the experienced programmer to construct commands to meet specific situations.

INTERCOM

The Intercom 101 permits operation of the G-15D as a decimal, floating point, single address computer with B registers. The simplified set of pseudo-codes (Table 12) can be used by relatively untrained personnel for non-repetitive problems where program preparation time must be minimized. Orders are written in a six-digit single-address form where the first two digits constitute a code specifying an operation. The next three digits form the address of a location in the interpretive memory, ranging from 000 to 863. When the operation requires no reference to the interpretive memory, the address 000 can be used. The sixth digit is 0, except when an index register is involved; in that case, any one of the eight sets of index registers can be specified. The six-digit order structure is *OP abc k;* where *OP* is the operation code, *abc* is the address of the operand—except for special commands, and *k* is the index register. Fig. 32 shows the program sheet for a sample problem—the addition of 14 and 328 using the Intercom system.

STANDARD PROGRAMMING

The standard set of commands must be used when the problem requires solution on a general-purpose computer in machine language. As the G-15D is a binary computer with decimal input and output, it is necessary to convert numbers and instructions into the binary machine language. This is done by a subroutine that takes the decimal "typein" number and automatically converts and stores it in the designated place in the memory. When typeout is called for, the binary number is converted by the sub-routine for decimal typeout. The use of paper tape or magnetic tape as the input or output medium, does not require conversion routines. Fig. 33 shows the program sheet for our sample problem, the addition of 14 and 328, using the standard commands listed in Table 11.

For repetitive problems, the possible modifications of basic commands make available block operations, double-precision arithmetic, minimum access coding and other functions that result in fast computer solution. The experienced programmer, using micro-coding techniques, can construct numerous special commands that use the computer's maximum potential. As many as 1300 commands are available with the micro-coding system.

LGP-30

The LGP-30 (Fig. 35) uses a magnetic-drum memory (see Fig 25B) with 64 tracks and heads. As each track can contain 64 words (a word has 32 bits), the drum has a bulk memory of 4096 words. A word length of 32 bits was used because this permits each word to represent one 9-place decimal number, which is adequate for most of the envisioned uses of this computer. As the drum rotates at 3600 rpm, any word is accessible in 17 ms—but an interlace technique of recording instructions and data is used on the drum (Fig. 34) so that the average access time is about 8 ms.

A program for our sample problem would be as follows:

Code	Instruction	Effect
0100	I 0000	Enter number 14 into accumulator with Flexowriter.
1101	C 4732	Transfer number 14 to memory location 4732.
0100	I 0000	Enter number 328 into accumulator.
1110	A 4732	Add contents of memory location 4732 to contents of accumulator and retain sum in accumulator.
1100	H 4733	Transfer sum to sector 33 of track 47.
0011	R YYYY	Set exit from print out routine (YYYY location of last instruction of output routine).
1010	U XXXX	Transfer to output sub-routine to print sum on typewriter (XXXX location of beginning of sub-routine).

We now have the sum printed on the report and also stored in memory for later use.

Alwac 111-E

The fundamental langauge for instruction given to Alwac (Fig. 38) is a hexadecimal number system. This is a 16-symbol code, and as there are only 10 arabic numerals it is customary to designate numbers 10 through 15 as letters. As 4 binary bits represent one hexadecimal column, any one hexadecimal digit can be represented by four bits. A partial list of instruction codes, by group, is given in Table II.

Arithmetic operations, such as addition, subtraction and multiplication, are performed in 3 registers known as the A, B, and D registers, each of which holds one word.

A word consists of 32 binary bits—equivalent to 8 hexadecimal characters plus sign. A typical word might be as shown in Fig. 37. Note in Fig. 37 that one part of the word is devoted to an instruction and the other part of the word is devoted to the

0 1 2 3	L	P	T or Lk	N	C	S	D	BP	NOTES
4 5 6 7			01	02	1	00	28		Clear and enter the number 14 (stored in line 00, word 01) in the accumulator.
8 9 10 11									
12 13 14 15			03	04	1	00	29		Add the number 328 (stored in line 00, word 03) in the accumulator.
16 17 18 19									
20 21 22 23			08	61	2	21	31		Mark place and transfer to binary to decimal conversion sub-routine.
24 25 26 27									
28 29 30 31			10	10	0	08	31		On return from sub-routine, type out contents of accumulator which now contains the converted number.
32 33 34 35									
36 37 38 39			12	00	0	16	31		Halt computation
40 41 42 43									
44 45 46 47									

Fig. 33. Addition of 14 and 328 using standard programming. It is assumed that the conversion sub-routine has been entered into the computer. The conversion and type-out commands can apply to only one number, as in the example, or to a block of numbers up to 106 words.

address; note also that each word of 32 binary digits represents two successive operations.

The program for our sample addition problem would proceed as follows:

INSTRUCTION	MEANING
2800	Command 28 means clear the accumulator. No address is needed so we write zeros for the address portion.
f143	Read our three-digit number (328) into the right end of the accumulator.
4912	Command 49 means store the number (328) in the selected cell (12).
2800	Again clear the accumulator.
f143	Read another three-digit number (014) into the accumulator.
6112	Command 61 means add the number (328) from cell 12 to the number (14) in the accumulator. The sum, 342, is now in the accumulator.
e713	Multiply by the proper power of ten (stored in cell 13) to place 342 at the left end of product register.
3200	Copy the product register to the accumulator (no address needed).
f543	Print the answer: 342.
1b00	Stop.

The instruction sheet for this sample problem is shown in Fig. 36.

E 101

Fig. 39 shows the ElectroData 101 general-purpose electronic digital computer. This desk-size computer uses magnetic-drum storage for data, pinboards for program instructions, and a modified bookkeeping machine for keyboard input and printed output. A paper-tape reader and punch can be attached for high-speed input and output.

The magnetic drum used for internal storage has a capacity of 100 or 220 computer words, each containing 12 digits plus a sign digit. The use of nine bits—small magnetized spots—for each digit stored on the drum permits straight decimal operation.

Programs are stored externally using pinboards —small frames in which special pins are inserted to specify program steps. Most operations are represented by familiar symbols, reducing the time required to learn how to use the computer: + is the instruction for add, P for print, etc.

Eight pinboards can be used at one time, each holding 16 instructions, for a total of 128 program steps. Any or all of the pinboards can be replaced for longer programs. Paper templates are used in pinning the boards; these can be marked and filed for convenience in future use of the same program. Automatic address modification is provided by program-controlled switches.

For output, 12 digits are printed in one operation and four motor bars control carriage travel to allow a choice of formats fitting the user's specifications.

LGP-30 Interlace Pattern

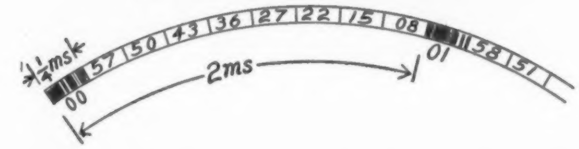


Fig. 34. Word 00 contains instruction 1. Word 01 contains instruction 2. However, 01 is placed 1/7th drum circumference away from 00, and 8 words are placed in the space between. This permits instruction 1 to apply to 6 of the 8 words between 00 and 01 before instruction 2 is reached—and permits a complete computer operation to occur in only 2.3 ms. Average access time can thus be reduced from 17 ms (one complete revolution of drum) to 8 ms.

Fig. 35. LGP-30 is a mobile, serial, single address, stored program computer.

00	28	00	f1	43	80
04	49	12	28	00	84
08	f1	43	69	12	88
0c	e7	13	32	00	8c
10	f5	43	1b	00	90

Fig. 36. ALWAC program for adding numbers.

BINARY	0	1111	0001	0000	1000	0100	1001	0010	0000	1
HEXADECIMAL	P_{33}	f	1	0	8	4	9	2	0	P_0
		INSTRUCTION		ADDRESS		INSTRUCTION		ADDRESS		

Fig. 37. One ALWAC instruction word has 8 hexadecimal digits (or 32 binary bits) plus sign. Note that this one word comprises two instructions and two addresses, and that each word of 32 binary digits represents two successive operations.

Fig. 38. Alwac III-E

Fig. 39. E101 computer in operation with capacity program on eight pinboards.

Fig. 41. Operator introduces input data into Elecom 50 using natural sequence ten-key keyboard which enables her to keep eyes on posting media at all times. Operator is shown making factory payroll on input machine. Output machine at left is simultaneously typing paychecks.

The main register is the accumulator, used in all internal handling of information. Keyboard entries go first to the accumulator, results are printed from the accumulator, and data passes through it going to or coming from the magnetic drum.

For example, the instruction **R34** means, "Read the contents of storage location 34 into the accumulator." A number also can be taken from the accumulator and sent to the B register, to internal storage, or printed by the appropriate command (Table 11).

In operating the E101, keyboard data entries are made when the computer is ready for them. The **K** instruction is placed in the program wherever new data will be required and, when that step is reached, the machine stops and the keyboard light goes on to call for more information. The operator then enters the number, up to 12 digits, on the keyboard and depresses one of the motor bars. At the same time that the information is sent to the accumulator, it is also printed; thus errors can be avoided by checking against the data sheet.

In the sample problem—adding 14 to 328—the procedure is as follows:

Step	Instruction	Meaning
Step 0:	K	Send 14 to accumulator when the operator enters it on the keyboard and depresses the motor bar.
Step 1:	W98	Store number now in accumulator in location 98.
Step 2:	K	Send 328 to accumulator after keyboard entry.
Step 3:	+98	Add contents of memory location 98 to contents of accumulator. (Sum is now in accumulator).
Step 4:	P	Print contents of accumulator (342).

These program steps are shown in Fig. 40 as marks on the paper template used as a guide for setting up the pinboard.

Elecom '50'

Data is introduced through a standard 10-key keyboard or through one or two punched paper tape reading mechanisms. Keyboard input is limited only by the operator's speed and, as a standard 10-key keyboard is used (Fig. 41), the touch method of operation permits entry of up to four digits per second (including motor bar depression). Punched tape is read at the much greater speed of 20 digits per second.

Data input can be made regardless of the position of the carriage and the input data can be printed or non-printed at any point. Thus, a series of inputs can be made without any printing or movement of the carriages. One or two printers and one of two tape punches are provided as a means of output.

A figure entered can be manually directed to a particular register by first entering the register number on the keyboard. It can be automatically directed by having the register number read in from paper tape. Also, the program control belt

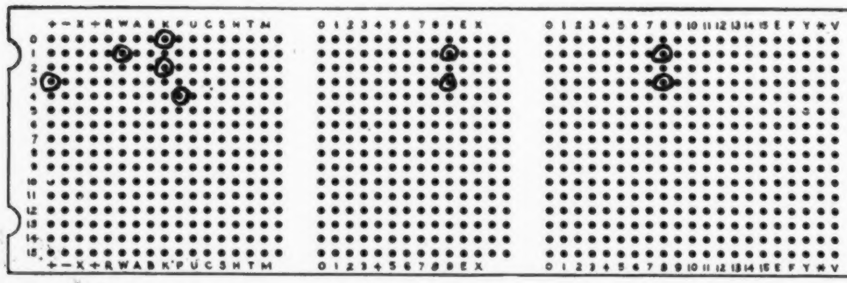


Fig. 40. Pinboard marked for sample problem. Follow each row across card for each operational step. Figures at top (or bottom) of each column identify operation and address.

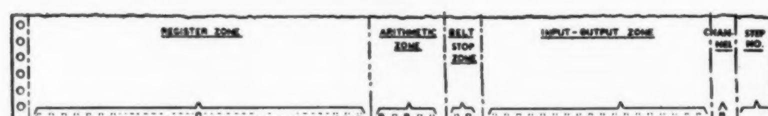


Fig. 42. Mylar program belt. All actions of the computer, the computations, the sequence of operations, the actions of the input and output devices, are controlled by the program belt. Register zone provides access to some or all memory locations. Instructions can be simultaneously recorded in the arithmetic, stop, and input and output zones. The Z code allows use of the second group of 50 registers.

(Fig. 42) can automatically direct a number to from one to fifty registers in one operation.

Data entered is automatically converted to binary form for storage. The information stored could be data constants or intermediate answers or totals. Each word in the memory has its own location or "address". Instructions are not stored in the memory; they are stored on the Mylar program control belt.

Data is stored in two 50-register (word) channels on a six-channel magnetic disc until required for arithmetic or output. Each register has 10-digit capacity and can take positive or negative figures and produce positive or negative balances. The drum makes a complete revolution in 1/30 second (1800 rpm). Control functions take an additional 1/30 second. Therefore, executing any arithmetic instructions involving registers takes a total of 1/15 second.

Addition and subtraction can take place between the contents of the 100 registers and the accumulator. It is thus possible to add (or subtract) a 10-digit number to (or from) as many as 50 other 10-digit numbers and to store the 50 results, all in two steps. In three steps, 100 registers can be affected in the same manner. It is also possible to add or subtract the contents of 50 memory registers at a time to or from the accumulator. Addition or subtraction can be automatically repeated as many times as required.

The instruction code of the Elecom 50 (Table 11) functions both to control the operations of the computer system and to provide means for selecting the locations of the registers. *Letters* of the instruction code serve to indicate arithmetic, logical, input, and output. *Numbers* of the instruction code serve to indicate memory locations.

Our sample addition problem (addition of 14 and 328) on the Elecom 50 would proceed as follows:

Step	Inst. Code	Register	Value
1. Enter amount by keyboard and store in register 22	ACDE	22	14
2. Enter amount by tape; add to previous contents of register 22	AEI	22	328
Value of register 22 after the above is 342, the sum.			
3. Clear accumulator; place sum in accumulator; set up dollars and cents sectors; print sum on report on main carriage and punch out on paper tape.	BEOSTW	22	342

This completes our look at five low-priced general-purpose digital computers. Next issue we will review the large data processing machines.

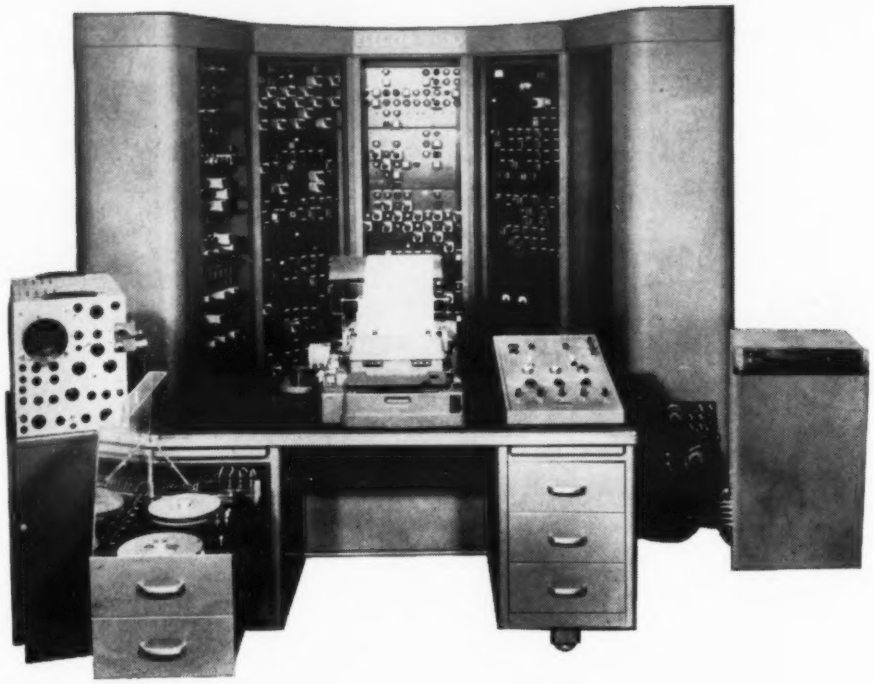


Fig. 1. Elecom 100 digital computer is used to check REAC solutions. (Photo courtesy Underwood Corporation)

The Use and Cost of ANALOG COMPUTERS

ERNEST A. GOETZ, ARMA DIV., AMERICAN BOSCH ARMA CORP.

Fig. 2. Project Cyclone Simulation Laboratory No. 1 contains 13 REACs, 14 servo units and 3 auxiliary computing cabinets with 420 computing amplifiers and 12 limiting amplifiers. (Photo courtesy Reeves Instrument Corp.)

MILITARY requirements are responsible for a tremendous amount of analog work, especially in the field of aerodynamics. Every aircraft and missile developed in the last few years has seen far more flying time in an analog computer than it has in the air. Missile developement, particularly, cannot afford much physical trial and error. Most of the debugging must be completed long before the first model is ever launched.

Probably the best known analog computer missile evaluation program is Project Cyclone, a program now about ten years old, being conducted by Reeves Instrument Corp. for the U. S. Navy Bureau of Aeronautics. One of several laboratories comprising Project Cyclone contains thirteen REAC computers (Fig. 2). With the thirteen computers is a considerable amount of auxiliary equipment—plotting boards, input-output equipment, function generators, etc. An Elecom 100 digital computer is used at Project Cyclone to run check solutions (Fig. 1).

Typical of the missile study program conducted at Project Cyclone is that of an air-to-air missile with its own seeker and guidance computer. The main objectives of this study are to investigate (1) roll-control under steering maneuvers; (2) the effect of various guidance methods on performance; (3) the error-sensing and resolving characteristics of the seeker. The basic block diagram of the simulation setup for this problem is shown in Fig. 3. The equipment used to instrument this problem included 304 amplifiers and 369 potentiometers. Fig. 4 shows solution plots of the REAC computer with superimposed digital check points. Note the close agreement between analog plot and digital check points.

It is interesting to note that the average running time for a single analog solution, that is, the time to complete one plot similar to that in Fig. 4, was approximately one minute. By comparison, the digital check solutions for all points on one plot took an average of approximately 75 hours. This demonstrates that for some dynamic problems with many input and output variables, the analog computer gives faster solutions with reasonably good accuracy.

Much of the evaluation in the missile study we have mentioned, and in other studies of which it is typical, concerns itself not only with the aerodynamic performance of the missile airframe proper, but also with the many servomechanisms involved in the guidance system and actuation of the control elements. This illustrates what is perhaps the classic example of the use of analog computers in design—namely, the analysis of linear servomechanisms.

A paper published earlier by members of the staff of Goodyear Aircraft Corporation provides a good illustration of the way an analog computer may be used in the design of an automatic milling machine. Fig. 6 shows a functional sketch of such a machine. In this case a master mold pattern is being duplicated. The probe shown at the top rides on the surface of the master pattern and actuates a pickoff which might be a potentiometer of a synchro transmitter. If the probe and cutting tool positions are not in perfect correspondence, an error signal is developed and amplified to drive the hydraulic machinery that positions the cutting tool. The design of this entire loop must meet certain stability and response criteria. The prime unknown is the design of the amplifier.

Here the analog computer becomes a useful tool. A block diagram of the proposed system is prepared as shown in Fig. 7. The known components can be represented in the block diagram *either by their transfer notation or by the differential equations describing their dynamic operation.*

Once this is done, a complete schematic can be drawn, as in Fig. 8. The voltage scales are assigned. Notice that a potentiometer is used in the control amplifier analog to allow variation of its transfer characteristic. The computer is then instrumented according to the schematic and the results displayed on a servo-driven XY plotter, showing the response of the cutting tool position. Through the use of the computer simulator, it was found that additional hydraulic control loops were necessary to damp out oscillations.

ECONOMIC AND RELIABILITY FACTORS

In considering an analog computer for a particular application, what are some of the costs, and what are some of the returns?

The user who is confronted with an application has two alternatives: He may purchase a computer or he may rent time on a computer.

Rental

Rental time on analog computers is available from a surprisingly large number of sources. The cost of renting analog computer time depends on the amount of equipment which you need for your problem. By way of example, a problem that was recently run on a rental facility by an Arma engineer required the use of approximately 100 amplifiers. The rental rate came out to about one dollar per amplifier per hour. In addition there is a charge of $15 per hour for the

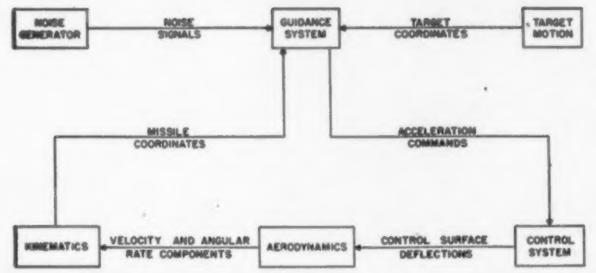


Fig. 3. Block diagram of 3-dimensional quided-missile problem involving guidance by computer circuit. Equipment used to simulate this problem included 304 amplifiers and 369 potentiometers.

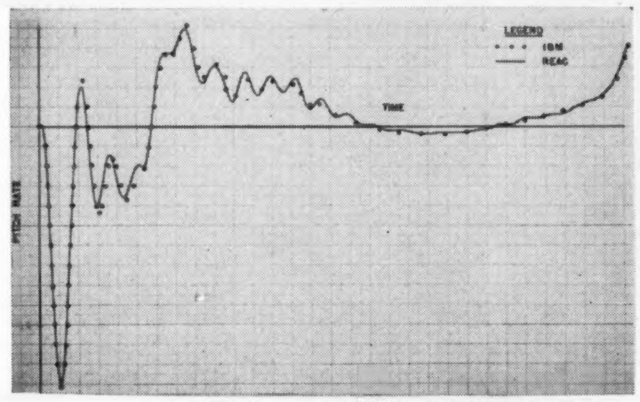


Fig. 4. Another variable desired was pitch rate of guided missile. Shown are analog-computer solution and digital-computer check. Note the close agreements.

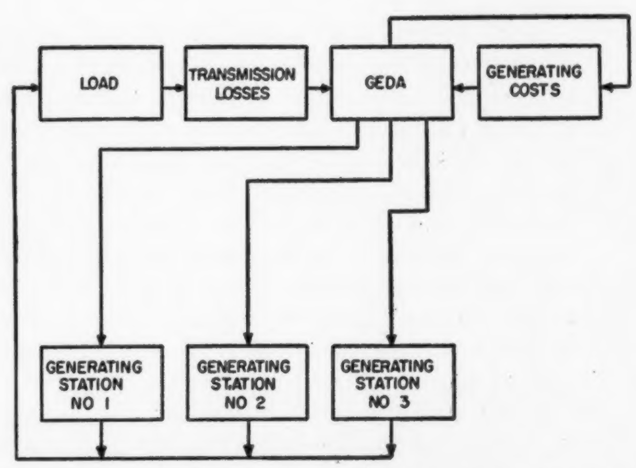


Fig. 5. Power-dispatch computer tells optimum operation of generating stations on basis of generating costs, transmission losses, and load.

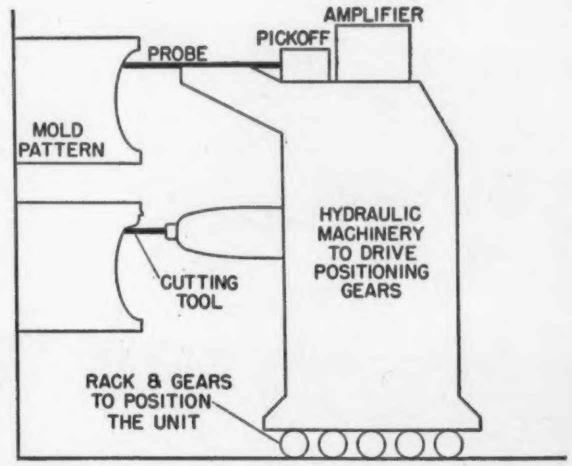


Fig. 6. Milling-machine problem involves questions (1) can system be stabilized? (2) is response speed sufficient? (3) what amplifier is required?

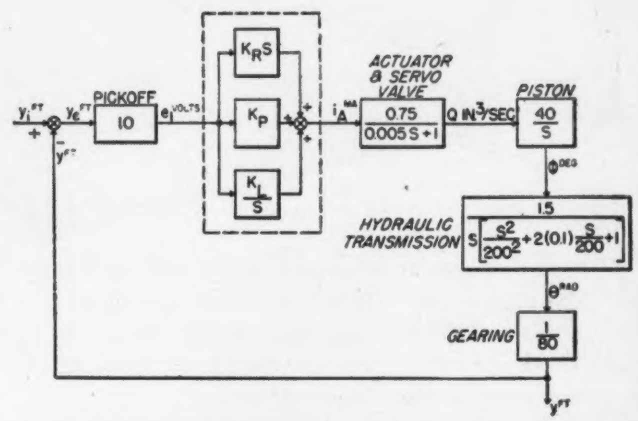


Fig. 7. Block diagram of milling-machine system with transfer-function description of each element.

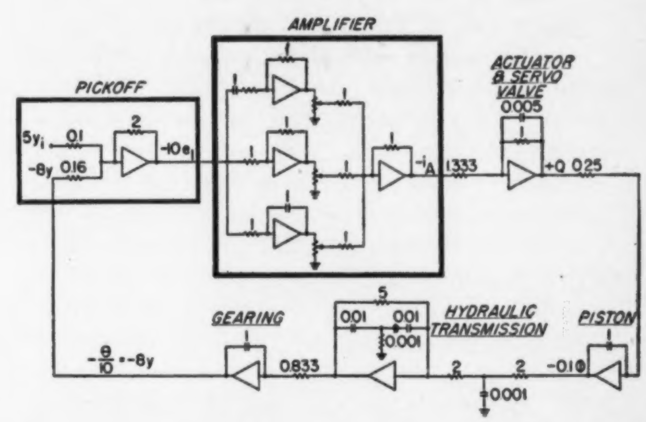


Fig. 8. Analog-computer diagram for system of Fig. 7 using 1:1 time scale. Final computer schematic used a 1:100 time scale (1 second of system operation corresponds to 100 seconds of computer simulation time) so that results can be plotted on an X-Y recorder.

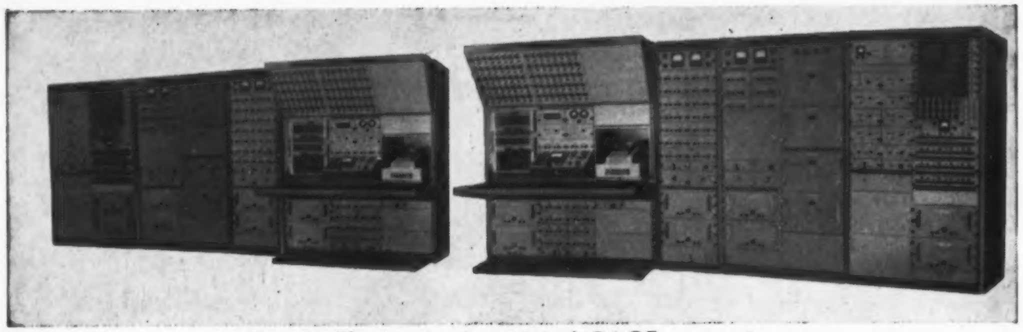


Fig. 9. Electronic Associates' PACE computer.

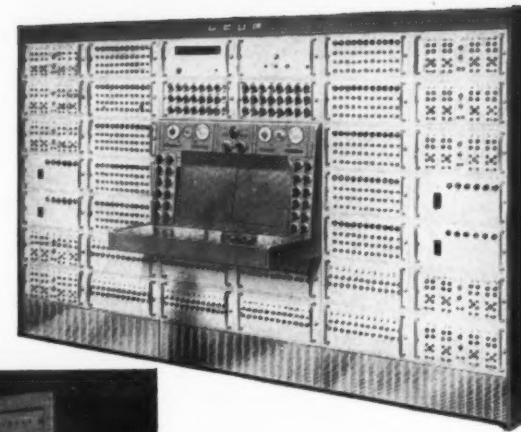
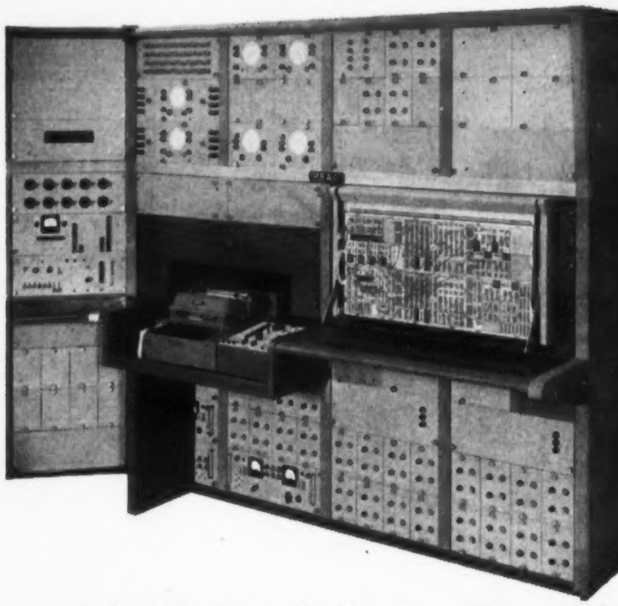


Fig. 10. New A14 expansible general-purpose analog computer combines functions of GEDA L3 and N3 units.



◄ Fig. 11 Reeves REAC with Auto-Control.

◄ Fig. 12. Expanded EASE computer of Berkeley Div., Beckman.

renter's engineer to assist in setup, making a total initial charge rate of $115 per hour. Of course this reduces to $100 per hour after completion of the setup. There are many computer problems which are much less complex than this instance.

Rental costs for government sponsored computational facilities may be lower than for the commercial ones.

Purchase

Suppose that the prospect is one of purchase rather than rental. In this case, I should like to suggest, if possible, a very early check, not only with suppliers, but also with other users in the same industry who have similar problems. You may be surprised at the willingness of people, even competitors, to tell you what they have learned, sometimes the hard way. At this point, it should be possible to make an estimate of the cost in manpower and purchases necessary for your in-plant setup. Basic items to be considered include (1) initial cost, (2) cost of plant space, (3) plant support-facility cost, such as ventilation, air-conditioning, and special electrical power connections, (4) operator manpower, and (5) maintenance and obsolescence costs.

From the point of view of amortization, some applications show a clear prospect of the computer paying for itself at regular, predictable rates over a period of years, for example, five years. In chemical processing, in power generation, in mass manufacturing business, costs are very often known to thousandths of a cent per unit output.

Applications where an analog computer can save many thousands of dollars per year are not uncommon in the category of control uses, but it is important to appreciate that, as in the case of an electric distribution network analysis (Fig. 5), the usefulness of the computer economically is likely to depend on the very careful analysis of differences between large quantities. Certainly engineers need not be reminded that accuracy is rquired in taking the difference between large numbers.

Aside from the dollar saving directly obtained from dispatch computers, power companies have found other advantages somewhat less tangible but probably equally useful. One such advantage is this: The system dispatcher finds it possible through the use of the computer to make more informed decisions about proposed system changes. He can determine whether the system is stable. When it is recalled what these determinations are made on the same working computer which previously has established the validity of its solutions by actual cost savings, it can be seen that confidence can be attached to the resulting predictions.

I think this is a good point at which to emphasize a very general concept relating to the use of analog computers, particularly for simulation. The idea has been known for a long time and so may not be new to you, but it may bear repeating. It is this: When we use a computer to simulate some process or system, what we are doing is manipulating the *computer* instead of the system itself. By so doing, we find out what would happen if such a thing were to be done in the actual system. The fundamental nature of this concept can be appreciated if we recall that the manipulation of substitutes—that is, of symbols instead of a real situation, is equivalent to the activity of thinking itself, and as a further parallel the psychological aims of thinking are precisely—economy and safety.

Another of the economic returns of analog computer use is the saving of engineering time. In addition to the saving obtained in speeding a numerical or graphical answer there is sometimes the gain of additional capabilities and insights. The kinesthetic "feel" or seat-of-the-pants familiarity obtainable in this way can be much more powerful as a conceptual tool than numerical answers alone.

In the same way we say that one value to be derived from an analog computer is a picture, a pattern. This sort of pattern, which we recognize as a whole, is called a *gestalt*. A *gestalt* is a meaningful pattern.

The engineer in a company who is best suited to profit from these engineering *gestalts* may well be the engineer who is most familiar with the practical aspects of the company's processes and products. It may also be the same person who can determine most readily how to set up the computer—that is, to determine from the physical situation the transfer functions to be used in instrumenting the problem on the computer.

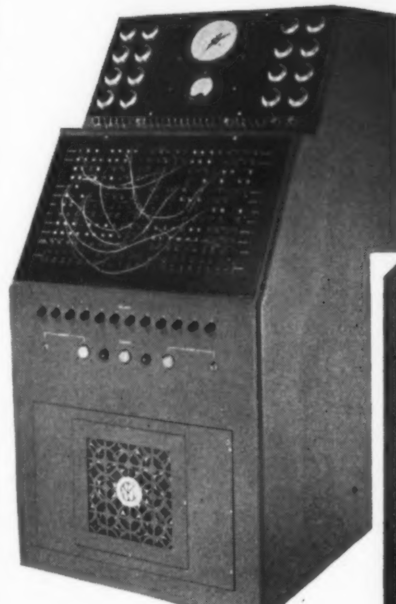


Fig. 13. Mid-Century MC-400 portable analog computer has 12 amplifiers, 1 servo.

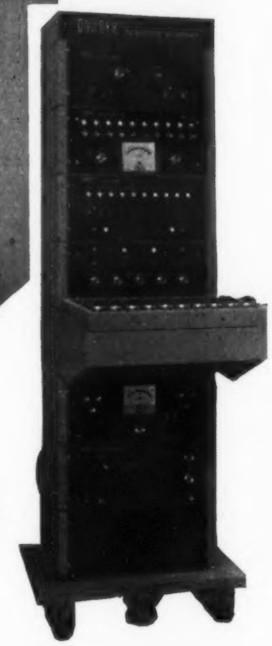


Fig. 14. Donner 3000 computer on movable base.

The engineer who is intimately familiar with the problem is not the only person in an organization who can set up and operate the analog computer. The point is that it is valuable to use fully this person's knowledge of the inputs and, wherever possible, to provide him the outputs in the form of the opportunity, so to speak, to fly the problem on the ground with his own hands.

Cost

Manufacturers offer a range of computer sizes and types. One measure of size is the number of amplifiers. A 15-amplifier desk-top computer is available from Heath. In the large machines, such as the PACE, GEDA, REAC, EASE, or Mid-Century (Figs. 9 to 13), up to several hundred amplifiers are offered. Very broadly, we might say that a 40-amplifier unit represents a medium size, and 100 amplifiers gets into the large computer category. The Donner 3000 computer (Fig. 14) can be classified as a medium-sized facility.

Basic prices also cover a wide range. You can buy a basic Heath desk-size computer for about \$700. Some larger machines can cost over \$1,000,000. A rough measure of price is \$1,000 per amplifier. Other important features of these commercial computers, aside from the types and numbers of operational amplifiers, are their control provisions, their checking features, their output devices, and provision for analog multiplication and various types and kinds of servo components.

FIRST SIGNAL CORPS POWER TRANSISTOR SPECIFICATION

THE SIGNAL CORPS has issued a specification for a power transistor to the Clevite Transistor Products Division of the Clevite Corp. for its type 2N297 transistor (Fig. 1). This is said to be the first specification from a military service for a power-type transistor.

This specification, MIL-T-12679/32 (SigC), is the first step toward JAN status which is awarded when this specification is also approved by the other military branches.

Besides meeting the usual military component specification for shock, vibration, centifuge, temperature and moisture resistance, the transistor's characteristics during the life test must also fall within the minimum and maximum variation limits which the Signal Corps has specified. Excerpts from the specification are shown below.

Fig. 1. 2N297 Power Transistor

MIL-T-12679/32 (Sig C)
INDIVIDUAL MILITARY SPECIFICATION SHEET
TRANSISTOR, POWER, GERMANIUM,
CTP 1107(2N297)

A. Ratings — TOTAL POWER

	VC_b Volts	P_t Watts	VE_b Volts	IE Amps	T_j
			Note 1	Note 2	Note 3
Absolute Maximum	−60	15	−9.0	5.0	85°C

B. General Test Conditions — Base Temp 25°C — Storage Temperature −55°C to +85°C

Note 1. VE_b denotes maximum reverse emitter bias voltage with $VC_b = -60$volts.

Note 2. IE denotes the maximum emitter current with $VC_b = 0$ and P_t not exceeding the maximum rating.

Note 3. T_j denotes maximum junction temperature. It is that temperature reached when the device is dissipating a power equal to P_t.

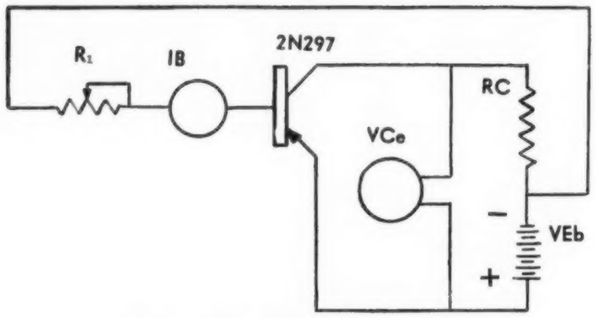


Fig. 2. Saturation Voltage Test

C. Initial Current Tests.

1. With collector bias at −6V and emitter current zero, collector current may not exceed 0.2 ma.
2. With collector bias at −60V and emitter current zero, collector current may not exceed 3.0 ma.
3. With emitter voltage at −6V and collector current at 0, the emitter current may not exceed 0.2 ma.

D. Initial Floating Potential Test. With collector bias at −60V and emitter current at 0, the floating potential may not exceed 180 mv.

E. Saturation Voltage (VC_e), to be measured in the manner indicated by Fig. 2, shall not exceed 1.0 volt when VE_b is −15V, RC is 7.0 ohns, and R1 is adjusted until IB is 300 ma.

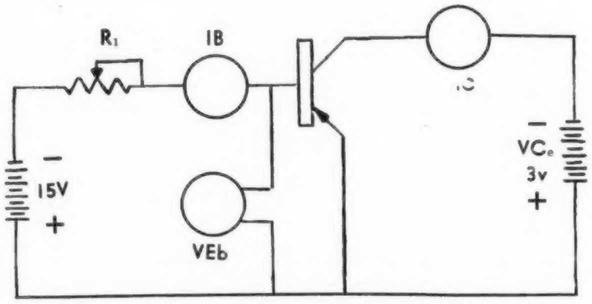


Fig. 3. HFE and GM Test

F. Large Signal Current gain, $HFE = \frac{IC}{IB}$, and transconductance, $GM = \frac{IC}{VE_b}$, are measured as indicated in Fig. 3.

1. HFE: Adjust R_1 until a 500 ma IC reading is obtained; then record the IB reading in ma. Calculate $HFE = \frac{IC}{IB}$, which shall have a minimum of 25 and maximum of 100. Repeat procedure with a 2.0 amp IC reading; $\frac{IC}{IB}$ shall have a minimum of 12 and a maximum of 40 Large Signal Current gain.
2. GM: With R_1 adjusted for a 500 ma IC reading record VE_b; calculate $GM = \frac{IC}{VE_b}$ Minimum 0.9 and maximum 1.8 mhos. Repeat with R_1 adjusted for 2.0-amp IC reading; GM minimum is 1.0 mho and maximum 3.0 mhos.

G. Frequency cutoff (FC_b) shall be measured as in Fig. 4. Adjust R_1 until a 500-ma IC reading is obtained. Set signal generator frequency to 1000 cps and adjust amplitude to that level which will result in 8.5V rms reading across 28-ohm load resistor (VTVM#2). Increase signal generator frequency, maintaining generator output amplitude constant (by observing VTVM#1) until the reading of VTVM#2 is reduced to 6.0 V rms (−3db). The cutoff frequency of the transistor is defined as the generator frequency at this point. Minimum cutoff frequency is 6.0 kc/sec.

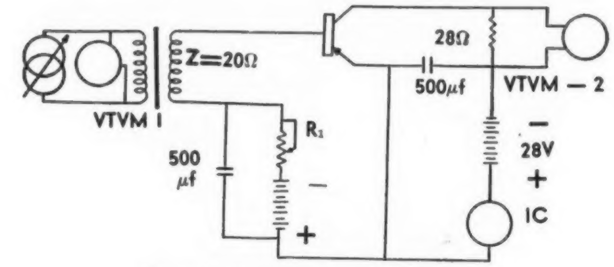


Fig. 4. Frequency Cutoff Test

H. Post 500 hour d-c life tests to be measured are:

1. With $VC_e = -3V$ and $IC = 500ma$, the ratio $\frac{HFE}{1 + HFE}$ should not decrease by more than 2%.
2. With $VC_b = -60V$ and $IE = 0$, ICO may rise to not more than 2 times initial value.
3. With $VE_b = -6V$ and $IC = 0$, IEO may rise to not more than 2 times initial value.

I. Other tests.

1. Soldering test and collector current, emitter current and floating-potential measurements to be made during the life test at the 24-, 96-, 240-, and 500-hour interval are also specified in the new specification.

For more information circle **204** on inquiry card.

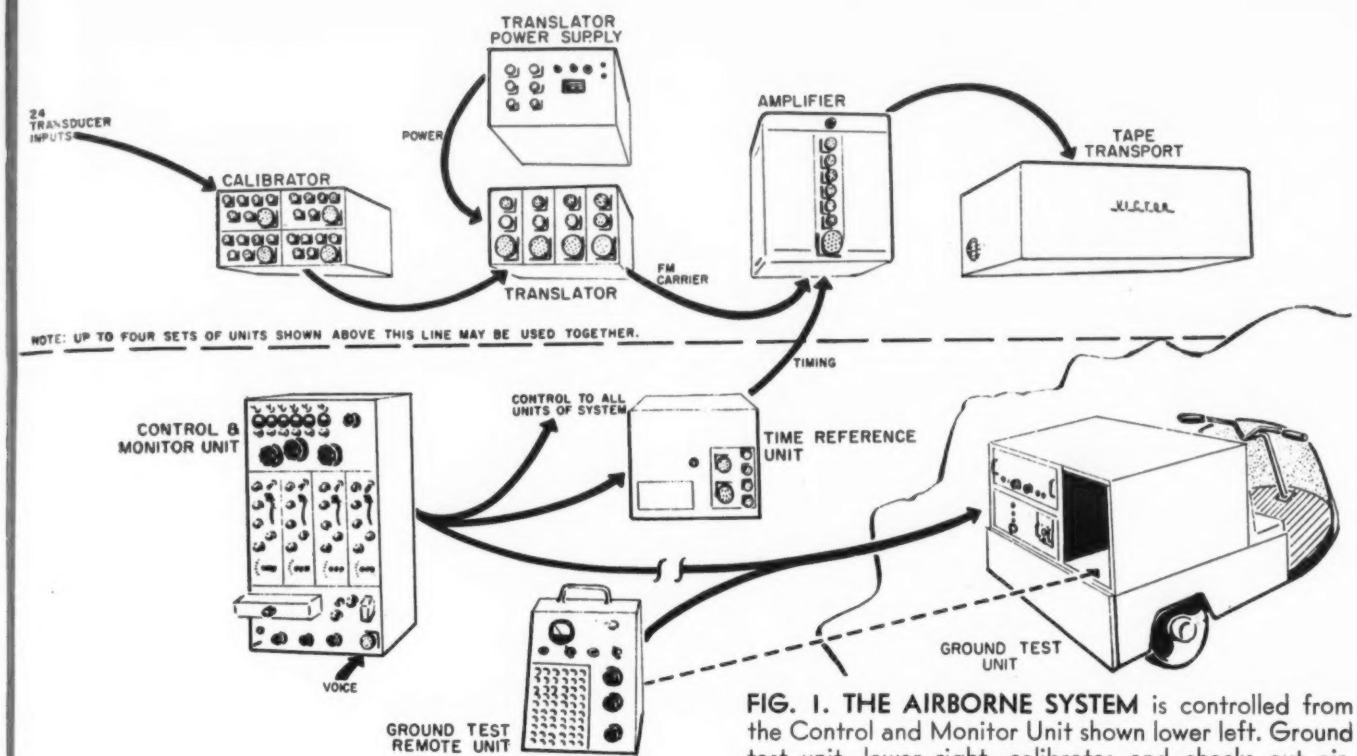


FIG. 1. THE AIRBORNE SYSTEM is controlled from the Control and Monitor Unit shown lower left. Ground test unit, lower right, calibrates and checks out airborne system before flight.

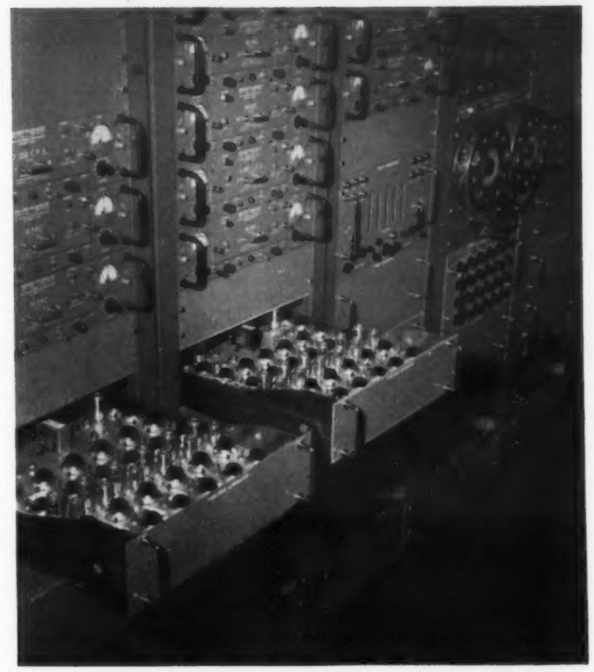


FIG. 2. GROUND DATA REDUCTION SYSTEM contains 24 FM demodulators and an audio channel for data reduction. It also contains the necessary correction circuits to correct zero drift and sensitivity changes in the data channels. It has wow and flutter air correction circuits as well as function generators to correct transducer non-linearities.

Flight Test Facts

A FLIGHT TEST data recorder has been designed and built by Victor Adding Machine Co. to the system specifications of Convair at Forth Worth, Texas. It is an FM system specifically designed to record data aboard an aircraft under flight test on magnetic tape acceptable to reduction equipment located at a ground station. Urgent data can be immediately telemetered to the ground, but it also is stored for later automatic processing through the ground reduction system.

Airborne System

The Airborne Data Recording system (Fig. 1) uses magnetic-tape recording of RDB carrier-frequency modulators, whose frequency varies in accordance with transducer output information. FM information is recorded on a 30-track, 3,000′, 1½″-wide magnetic tape for a maximum of 40 minutes of continuous recording: 25 tracks are used for data (which includes a voice channel); 4 tracks are used for reference signals for error correction, for timing and calibration markers, and for addressing the data on the tape with real-time coding; 1 track is a spare. Normally, 4 tape transports are included in the airborne system to give 100 simultaneous tracks of continuous data.

Commercially-available FM modulators of the resistance-bridge-controlled, voltage-controlled, and inductance-controlled variety are employed to place from 1 to 6 standard RDB carrier frequencies (channel 8 to channel 13) on each tape track. Thus the 100 tracks simultaneously provide 600 channels of information.

Ground Reduction System

The primary function of the ground reduction system (Fig. 2) is to remove the analog information contained in the frequency-modulated carrier and present this to an oscillograph or pen recorder.

An analog-to-digital converter also can sample the analog information at rates up to 1,000 samples per second, convert the information to digital form, frame the information for immediate use as an input to a large-scale digital computer, and record the information in digital form on tape. The sampling rate commands are keyed by timing signals on the original magnetic tape.

Each of 24 demodulators provided in the ground reduction system can be switched to any tape track to provide simultaneous output from 24 information channels.

When the data are processed through the ground reduction system, the following corrections are provided:

(a) Mechanical wow and flutter corrections to eliminate errors of low frequency wow are accomplished through a servo system.

(b) Electronic wow and flutter corrections eliminate errors of low and high frequency caused by changes in tape-to-magnetic-head velocity relationships. A crystal-controlled frequency recorded on the tape is discriminated to provide frequency corrections to the data discriminators.

(c) The data discriminators are adjusted automatically to correct errors due to variations in center frequency (zero shifts) or variations in sensitivity (gain shifts) in the components of the system from modulators to demodulators. A servo system provides these corrections.

(d) A correction for nonlinear transducers is provided by a function generator which gives a linear output for a non-linear input.

Data are addressed every ten seconds while being recorded. Data can be located and read-out starting with any second interval. The data read-out may be stopped at any selected address. A function of repeated read-out between two selected addresses also can be used.

Information recorded on different carrier frequencies is reproduced in correct time correlation so that the time relationship of signal inputs is maintained. The power requirement is 20 kw from a 208/115v, 4-wire, 3-phase, 60-cps power line which should have a 30-kw capacity to provide for surges.

The pre-flight portable test cart (Fig. 1), together with the control section of the airborne system provides electronic test equipment for the precise alignment and inspection of the airborne system components.

For more information circle **205** on inquiry card.

FIG. 1. ARMY 75MM "Skysweeper" will spot, track, aim and fire automatically at enemy jet aircraft (US Army Photo)

SERVOS

Kenneth L. King, Director of Research and Development, Norden-Ketay Corporation, has been an executive of Norden-Ketay since 1947. He has directed many Research and Development programs requiring advanced servo systems including complete bombing and navigation systems, stabilizing systems, and computing systems. Mr. King had previously been associated with Bell Laboratories for seventeen years, where he supervised the MK 15 Bombing Radar Systems and other microwave programs.

KENNETH L. KING Norden-Ketay Corporation

CLAUDE O. MORRISON Military Automation

This begins a tutorial series on servomechanisms. Later issues will cover the basic elements of electro-electronic servo systems, synchros, sensing and actuator devices, and amplifiers. Hydraulic synchro devices used in military applications will be included.

A SERVO SYSTEM is a control system in which a variation in an input position produces a proportional variation in output position. Servo systems, if not specifically designated *open loop*, are considered to be *closed loop*—that is, the output "feeds back" a signal to be compared with the input signal. A comparison device compares the feedback and input signals to assure that the latter is proportional to the former. In open-loop servos, by contrast, the judgment and action of a human operator is usually necessary to monitor and adjust the output.

The servo system is usually a power amplifier. The controlling force or signal is ordinarily quite small compared to the force which actuates the output motion. The high power output is obtained from electrical, pneumatic or hydraulic sources of power. Because these sources of power act as a "slave" to the controlling input, the term "servomechanism" meaning "slave-machine" is appropriate.

Servomechanisms are widely employed in military equipment to relieve pilot monotony when steering ships and aircraft, and also to accomplish jobs beyond human strength or coordination, achieving fire-control for gun batteries, holding a telescope sight on a star, or maintaining a level platform despite various motions of a ship or carrier. Other types of servos can control rates and acceleration or can perform calculations. Fig. 2 illustrates the numerous applications of servos, gyros and accelerometers applied in a single Air Force fighter. The operation of guided and ballistic missiles depends on servo systems, and our missile program is today creating a great market for lightweight, accurate servomechanisms.

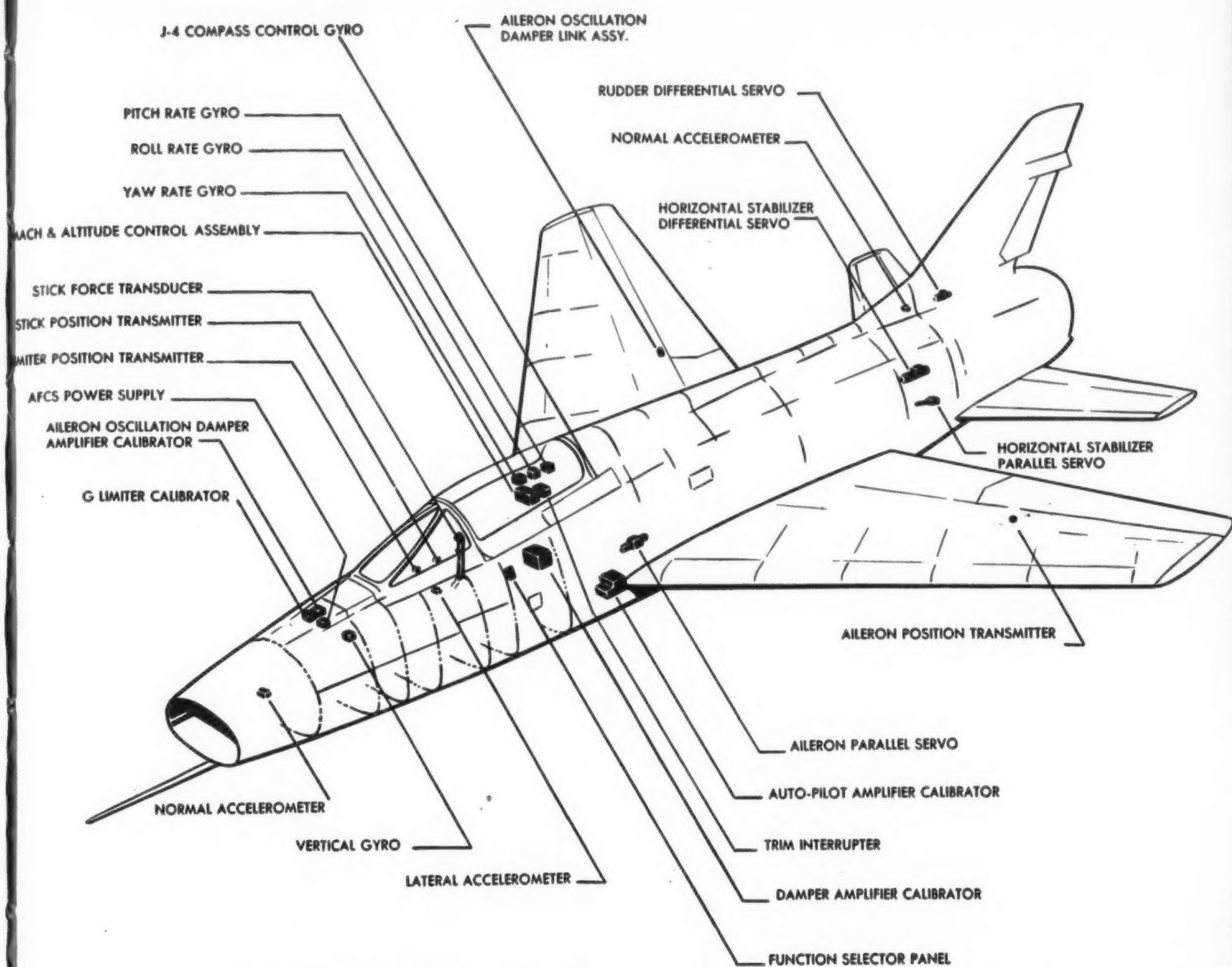


FIG. 2. SERVO SYSTEM elements used in the Minneapolis-Honeywell MB-3 automatic flight control system for the North American F-100 D Super Sabre supersonic Air-Force jet fighter. Other servo systems in radar, firecontrol, etc., of this plane are not shown. (Courtesy Minneapolis-Honeywell Co.)

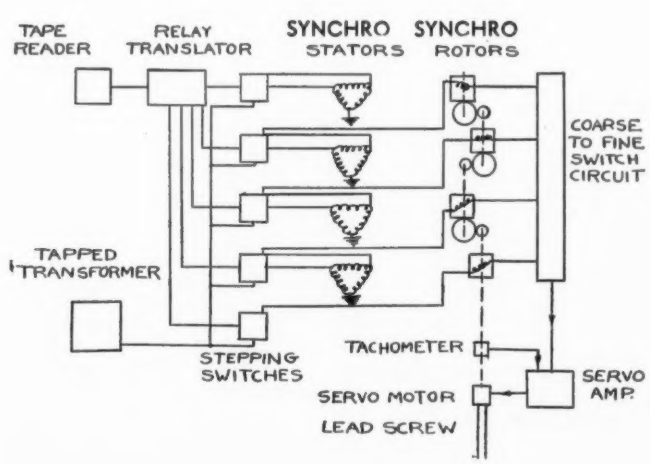
FIG. 3. THE SPERRY GYROFIN stabilizer installed in the USS Compass Island reduces ship roll to one-tenth that of unstabilized sister ships. Servo systems compute stabilizing moment and transmit amplified anti-roll signals to hydraulically-actuated fin shown. (Courtesy Sperry Gyroscope Co.)

Fig. 1 shows a 75-mm anti-aircraft gun equipped with a radar that will hold itself pointed on the target. Signal energy reflected from a jet plane four miles away controls the servo that drives the slewing and pointing motors.

Stabilization of ocean-going ships in heavy seas is achieved by giant fins (Fig. 3) which counter the natural roll and pitch motions of the ship. The fins are moved by hydraulic actuators controlled through servos from stable-element gyros.

Fig. 4 shows use of a servo to control milling and other automatic machines to accomplish production schedules impossible with manual operation.

The basic principles and components of servo systems, synchros, sensing and actuator devices, and the use of servos as computers will be explained in future articles of this series.



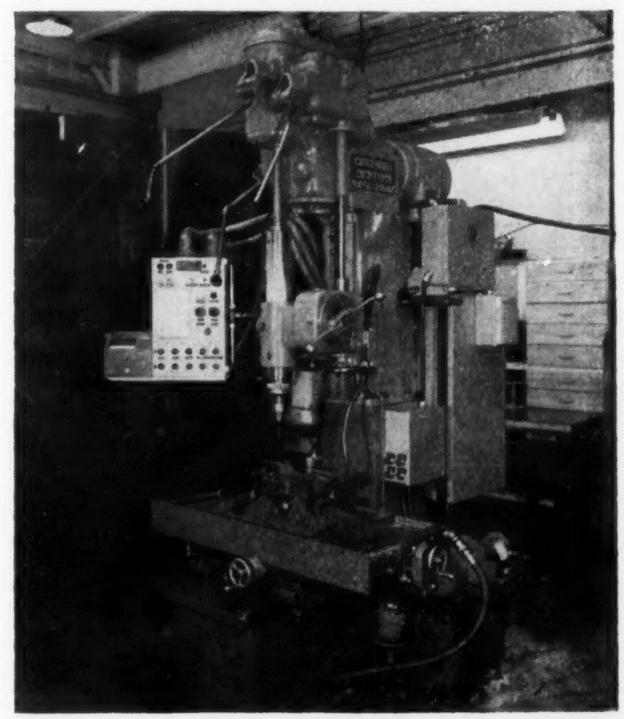
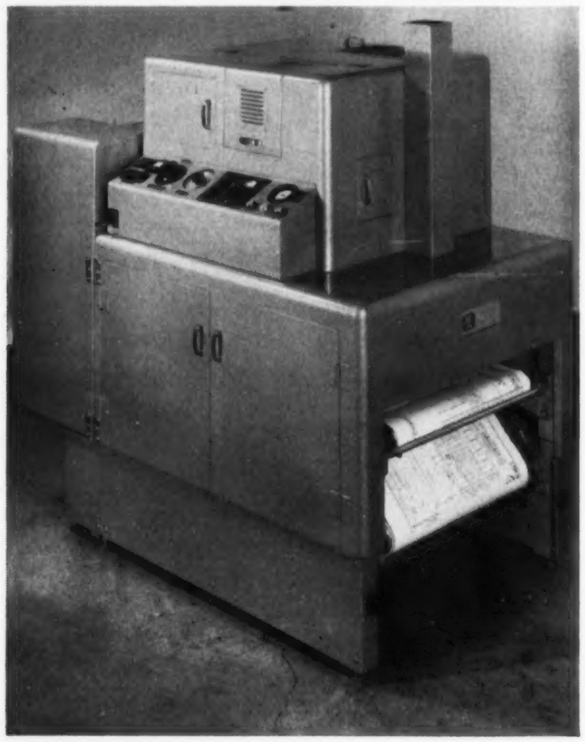


FIG. 4. AUTOMATIC-MACHINE servos controlled from punched tape speed production in ordnance and aircraft factories. Automatic positioning of drilling machine work table is shown at right. Block diagram at left shows how electrical and hydraulic servos are combined for accuracy and flexibility. (Courtesy Advance Industries, Inc.)

MA New Products

DRAWINGS AT 20'/MIN.

Naval Aviation Supply Office, Philadelphia, uses this XeroX® Copyflo® 24-inch continuous printer for xerographically reproducing microfilmed engineering drawings for engineer's use. Individual film frames are mounted in IBM or Remington Rand tabulating cards which are handled and filed by Filmsort techniques. Copyflo printer

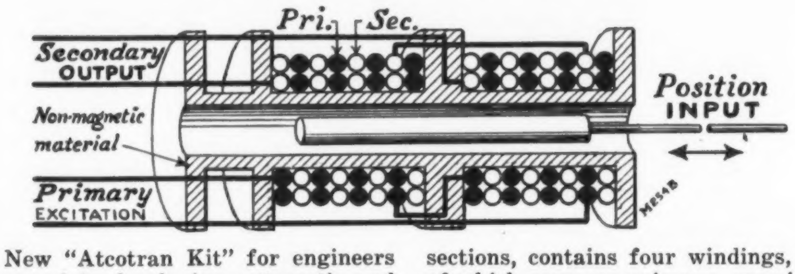


produces 24-inch-wide engineering drawings on inexpensive uncoated paper at rate of 20'/min. No ink, chemicals or darkroom is needed. Each film may be reproduced as many times as desired, at an estimated cost of 12c per copy. A detailed story will appear soon in *MA* covering all phases of the Filmsort program being instituted by the Bureau of Aeronautics at the ASO. Xerox Copyflo printer is a development of *The Haloid Co., Rochester, N. Y.*

For more information circle **301** on inquiry card.

FOR MORE INFORMATION ON ANY OF THE PRODUCTS REPORTED IN THIS SECTION, CIRCLE THE ITEM NUMBER ON THE INQUIRY CARD BOUND IN THE FRONT OR BACK OF THIS ISSUE. IF THE CARDS HAVE ALREADY BEEN USED, MARK THE ITEM NUMBER AND DATE OF THIS ISSUE ON A POSTAL CARD AND MAIL IN CARE OF OUR READER SERVICE DEPT.

DIFFERENTIAL TRANSFORMER KIT



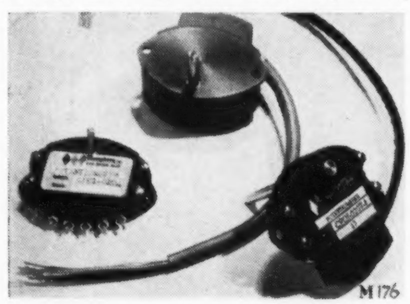
New "Atcotran Kit" for engineers engaged in developing automatic and computing devices facilitates conversion of linear displacements to electrical signals. Position change as small as 0.001" can be sensed under experimental and test conditions. Coil structure of "Atcotran" differential transformers, divided into two main sections, contains four windings, two of which serve as primary, remaining two as secondary. (Small section at left end of coil form is used to house interconnections and lead wire terminations.) Design insures equal and stable electrostatic coupling between primary and secondary windings and minimizes temperature drift due to

changes in such coupling. Kit consists of seven complete differential transformers having a linear range from ±0.01" to ±2.5", a flexure plate and clamp for positioning coils; a demodulator which converts ac output of differential transformer to dc voltage; 32-page "Transducer Handbook" which describes theory, development and use of differential transformers and provides curves and tubular data. One section of Handbook covers application circuits, another accessory control equipment.—*Automatic Temperature Control Co.*, 5200 *Pulaski Ave., Philadelphia* 44, *Pa.*

For more information circle **302** on inquiry card.

GONIOMETRIC VDRs

New "Models CP01-0103-1, CP01-0207-1 and CP01-0204-1" sector-form voltage-dividing resistors, especially

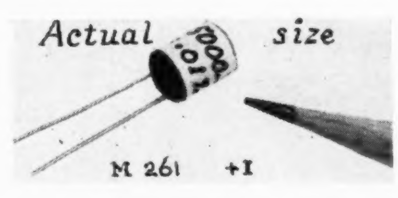


engineered for control systems and instrumentation in aircraft and missle systems; are designed to measure angles from zero to 90° of shaft rotation. Accuracy 0.5%; resolution 0.10°. Units, withstand vibration, shock, and temperatures to 300°F.—*Humphrey Inc.*, 2805 *Canon St., San Diego* 6, *Calif.*

For more information circle **303** on inquiry card.

MINIATURE RESISTOR

New "Type 287 Precision Wire Wound Resistor," designed for critical applications, requiring lab accuracy and stability in minimum space, utilizes special winding and encapsulating techniques, features 0.01% absolute resistance accuracy in values

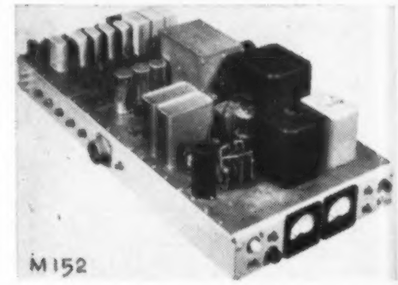


above 100 ohms, 0.005% accuracy in values above 1000 ohms; 10 ppm temperature coefficient; 0.003% resistance stability; 0.2 w power dissipation.—*Consolidated Resistance Co. of America, Inc.*, 44 *Prospect St., Yonkers, N. Y.*

For more information circle **304** on inquiry card.

RADAR PULSE SIMULATOR

New radar mark generator simulates both range timing pulses and 10° and 30° azimuth pulses in per-

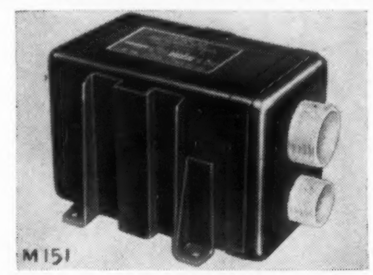


sonnel training or in radar equipment design; is completely self-contained in portable case or relay rack-mount and has its own power supply. Range marks are generated from a crystal oscillator with extreme accuracy and negligible phase jitter. Azimuth marks are generated with less than 0.5° variable error.—*Advanced Electronics Mfg. Corp.*, 2025 *Pontius Ave., Los Angeles* 25, *Calif.*

For more information circle **305** on inquiry card.

AUTOMATIC MISSILE PROGRAM CONTROLLER

New "Fire Control Intervalometer," built for service in today's jet aircraft, provides automatic program-



ming for missile firing: opening of rocket pods, rocket launcher extension, etc. and other functions in complete and proper sequence of a firing mission are controlled to millisecond accuracies. ★Incorporated in some of maker's intervalometers is "Chronopulse" time generator, a new type of high-accuracy dc time base.—*Abrams Instrument Corp.*, 606 *E. Shiawassee St., Lansing* 1, *Mich.*

For more information circle **306** on inquiry card.

SIGNAL SOURCES

New "FXR Type No. S771A Broadband Microwave Signal Sources," packaged into one compact unit, fea-

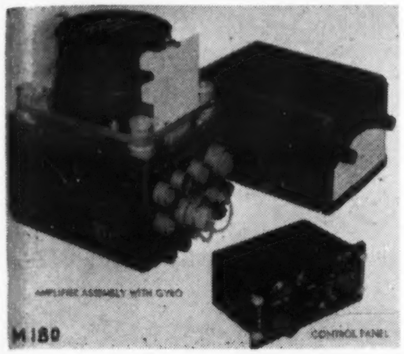
ture a direct-reading frequency dial that offers "one-knob control" from 950 to 2000 and 1900 to 4000 Mc; com-

bine a power supply, klystron, kylstron cavity, modulator, variable rf attenuator and an automatic reflector voltage tracking system; permit broad-band measurements to be made with increased speed and ease. —*F-R Machine Works, Inc.*, 26-12 *Borough Pl., Woodside 77, N. Y.*

For more information circle **307** on inquiry card.

COMPASS SYSTEM

New "Type MA-1" aircraft compass system (developed by maker for Navy BuAer) is an all-purpose gyro-

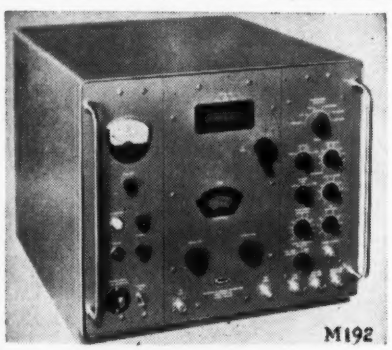


slaved directional system designed for use under all operating conditions including high latitudes where ordinary compasses become unreliable. Among features: High accuracy directional gyro with a random drift rate of less than 4° per hour; tubeless amplifier using silicon transistors and mag amps; light weight (16.7 lb); multiple indicators which can provide course readings at up to three different remote locations in aircraft. —*Lear, Inc., Grand Rapids, Mich.*

For more information circle **308** on inquiry card.

ULTRA BROADBAND MICROWAVE SIGNAL GENERATOR

New "MSG-34" is said to cover a frequency range "equal to two or more present day units": S, C and X



bands (4,200 to 11,000 Mc) with a power output of 1 mw; is equipped with maker's "Uni-Dial" construction which provides complete integration and simple operation. Large direct-reading dials indicate frequency and attenuation. Among other features: provision for external modulation by multiple pulses; automatically tracked power monitor; and non-contacting oscillator choke.—*Polarad Electronics Corp.*, 43-20 *34th St., Long Island City* 1, *N. Y.*

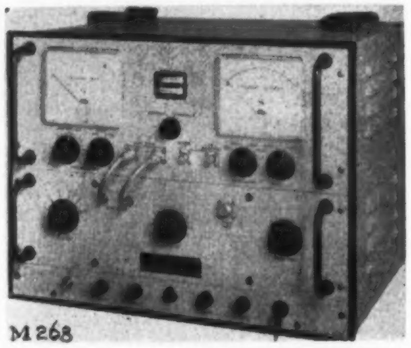
For more information circle **309** on inquiry card.

You Get Things Done With Boardmaster Visual Control

New Products—*Continued*

STABILITY TESTER

New "Model 5004 Microwave Stability Tester" measures changes in frequency of microwave oscillators to a new high degree of precision: at S-band, the change that can be indicated is less than 2 cps. Instrument

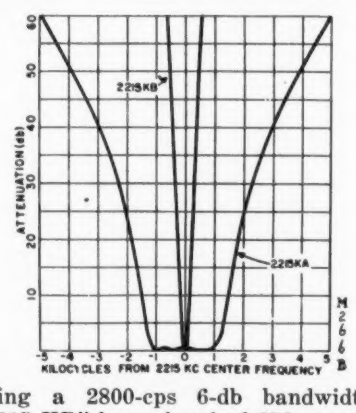


measures drift and rate of drift of oscillators; therefore has many applications where determination of stability is important. It is adaptable to take readings at S-, L-, C- or X-band; can take stability measurements at 30 Mc and from 30 kc to 230 kc. Feature: readings can be taken instantaneously and monitored continuously. —*Laboratory for Electronics, Inc., 75 Pitts St., Boston 14, Mass.*

For more information circle **310** on inquiry card.

CRYSTAL FILTERS

New "Models 2215-KA and 2215 KB High-frequency Band-pass Crystal Filter" make it possible to build a receiver that overcomes disadvantages of multiple conversions while retaining practically all advantages. "Model 2215 KA" is designed for voice uti-

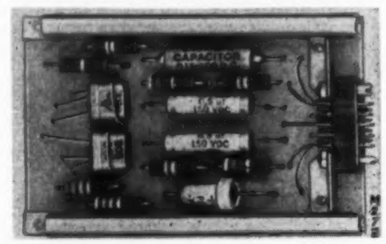


lizing a 2800-cps 6-db bandwidth; "2215 KB" has a band of 250 cps and is of primary interest in CW reception. Both are electrically and mechanically interchangeable; can be cascaded in any combination to achieve selectable selectivity; can be incorporated between mixer and IF. amplifier of a single conversion receiver; come with complete instructions including mixer and IF circuitry.—*Hycon Eastern, Inc., 75 Cambridge Parkway, Cambridge 42, Mass.*

For more information circle **311** on inquiry card.

SUMMATION AMPLIFIER

New "Model 807" single-channel completely transistorized series summation amplifier is a small lightweight reliable unit, designed for use as an isolation amplifier with any standard 400-cps resolver. It provides

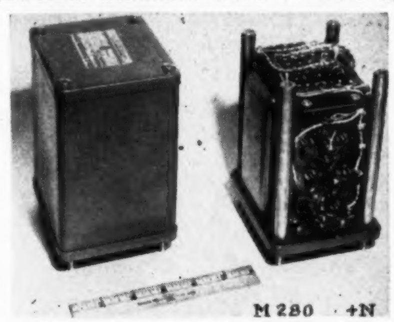


complete compensation for phase shift errors and non-linearities caused by inductance, reactance, etc., of resolver systems. It maintains inherent resolver accuracies by offering an extremely high impedance to the driving resolver and low impedance to the driver resolver. Operating life of over 8000 hours; accuracy better than 0.1%; phase shift errors less than 0.15°; operating efficiency over 90%; temperature range —55°C to 85°C.—*Maxson Instruments Div., W. L. Maxson Corp., 47-37 Austelle Place, Long Island City, N. Y.*

For more information circle **312** on inquiry card.

DC TO AC POWER SUPPLIES

New light-weight tubeless highly efficient dc and ac power converters enable portable, aircraft, and vehicular electronic equipment to be battery-powered. Standard units produce up



to 250 va from 28 vdc input; custom units up to 2 kva; also dc to 3-phase. Units can be made to meet MIL specs; can be as light as ½ oz per va. Typical of this series is "Model UAC 100VA/115-1000" which delivers 100 va (100 vac, 1000 cps at 1 amp) and weighs 3½ lb.—*UAC Electronics Div., Universal Transistor Products Corp., 143 E. 49th St., New York 17, N. Y.*

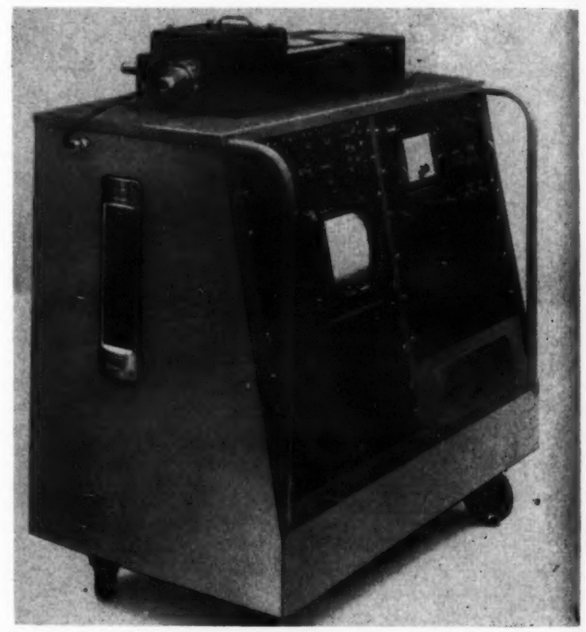
For more information circle **313** on inquiry card.

Lit Bits—*Continued*

Airborne Particulate Radioactivity

Isotopes present in the atmosphere as particulates, adhering to particles of dust, can be concentrated by drawing a large quantity of air through an efficient filter. For example, if 200 cubic feet of air are drawn through a filter paper which collects all of the particulate activity present in this volume, the radiation from activity collected when the concentration is 2 x 10^{-12} $\mu c/cc$ is approximately 100 dpm. This amount of activity is readily measured by standard counting techniques.

Devices for monitoring fiterable radioactivity in the atmosphere are of two types—the fixed filter, or the continuously moving filter. The fixed filter is constructed so that air is drawn through a filter at a



Mobile, continuous filter unit.

known rate for a measured period of time. The exposed filter is then removed from the sampler and monitored for radioactivity.

The continuous filter system records the level of radioactivity collected on a moving tape of filter paper. The rate at which the sample is drawn through the filter paper and the speed of the moving filter, when combined with the counting rate, permit calculation of the concentration of radioactivity in the atmosphere on a continuous basis. (*From new 8-page Bulletin RM1-100, Tracerlab Inc., 130 High St., Boston 10, Mass.*)

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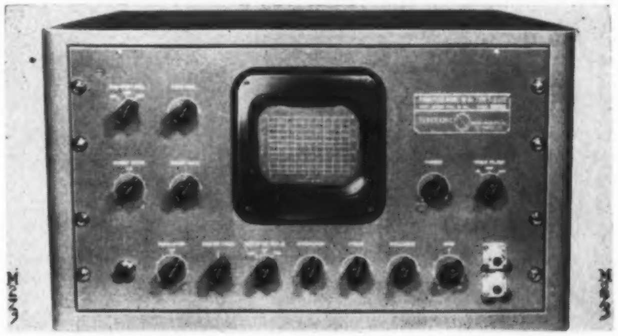


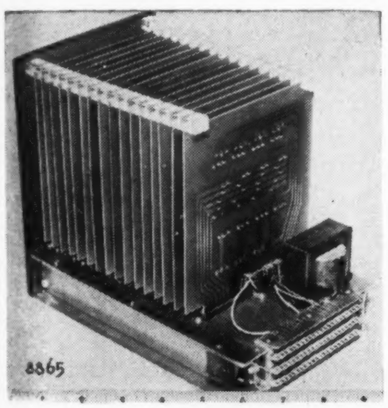
PANORAMIC-TYPE SPECTRUM ANALYZER

Three newly improved types of "Model SB-8b Panalyzors" have (a) continuously-variable sweepwidth from maximum to 0; (b) continuously variable scanning rate from 1 through 60 sps with one control and three selectable modes: free running, line sync or external sync; (c) three selectable types of amplitude displays: linear, log or square law; (d) flat-face CRT with edge-lit calibrated screen and camera mount bezel. ★ (1) "Type T-10,000" has differential markers to show frequency dispersion, 10-Mc maximum sweepwidth and resolution range from 100 kc to 9 kc; (2) "T-1000" has 1-Mc maximum sweepwidth and resolution range from 10 kc to 200 cps; (3) "T-200" has 200-kc maximum sweepwidth and resolution range from 4.5 kc to 50 cps.—*Panoramic Radio Products, Inc., 10 S. 2nd St., Mount Vernon, N. Y.*

For more information circle **314** on inquiry card.

DIGITAL COMPARATOR

New digital comparator, for use in digital servo control systems, makes possible true digital control without recourse to counting techniques. In conjunction with maker's 13-bit or 19-bit shaft position encoder, it can provide digital control through conven-



tional servo amplifiers and motors. This enables application of digital control to existing servo systems with least change of components. Using no relays or tubes, comparator can be readily packaged for rugged environments and with great flexibility of configuration.—*Norden-Ketay Corp., Commerce Road, Stamford, Conn.*

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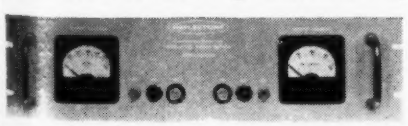
LABORATORY POWER SUPPLIES

Two new lab power supplies give different output ranges: "Model PS-L225" for 125-325 v @ 0-200 ma dc,



6.3 v @ 10 amp ac; and "Model PS-L425" for 325-525 vdc range. Both have regulation better than 0.25% against load and line and ripple less than 3 mv rms; are designed for heavy-duty continuous operation; incorporate protection against overloads or internal failure. Input 105-125 v, 50-400 cps.—*Reflectone Corp., Stamford, Conn.*

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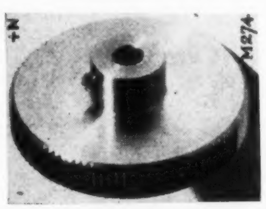
KNURLED KNOBS

New "Type BG" precision knurled knobs are available in three shaft



sizes: ⅛", $\frac{3}{16}$" and ¼". Knob diameters range from 1" to 2". Material: #303 stainless steel, clear passivated. —*PIC Design Corp., 477 Atlantic Ave., East Rockaway, N. Y.*

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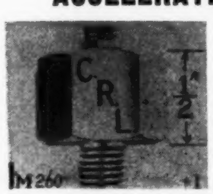
ACCELERATION PICKUPS

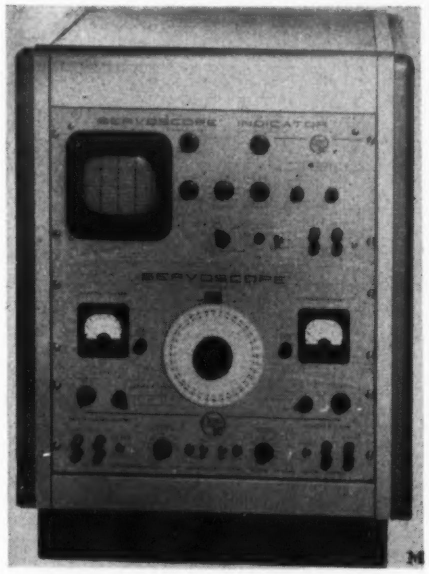


New "Series 400" piezoelectric acceleration pickups, employing barium titanate in compression for operation over extremely wide acceleration and frequency ranges, have a natural frequency of 75 kc, a usable acceleration range from 0.03 to 40,000 *G*, a frequency range from 0.05 to 20,000 cps, and a sensitivity of 30 mv/*G*. Other pickups with various sizes, weights, mounting configurations and sensitivities available.—*Columbia Research Labs., Woodlyn, Penna.*

For more information circle **318** on inquiry card.

SERVO SYSTEM ANALYZER

New "Model F Servoscope" measures frequencies from 0.005 cps (one cycle in 3⅓ min) to 100 cps; provides sine, modulated sine and square-wave signals as well as linear sweep on four ranges. For less exacting requirements, maker offers four other



models: all five will accept carrier frequencies of 50 to 5000 cps from the same source used for system under test.—*Servo Corporation of America, 20-20 Jericho Turnpike, New Hyde Park, N. Y.*

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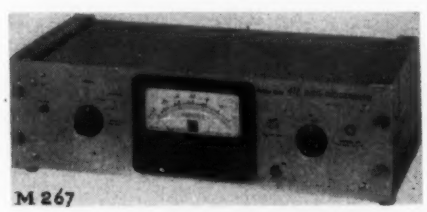

MICROMICROAMMETER

New "Model 412" logarithmic micromicroammeter features a single 6" scale indicator covering six decades from 10^{-13} to 10^{-7} amp; is extremely stable; economical in cost, and has exceptionally fast response: less than 2 sec to 90% for currents larger than 10^{-12} amp with 5000 mmf across input. Zero drift is within 0.5 decade in 8 hr. A 216-v tap for polarizing ion chambers is provided and a 6-v output (proportional to input) can drive either 50-mv or 5-ma recorders.—*Keithley Instruments, Inc., 12415 Euclid Ave., Cleveland 6, Ohio.*

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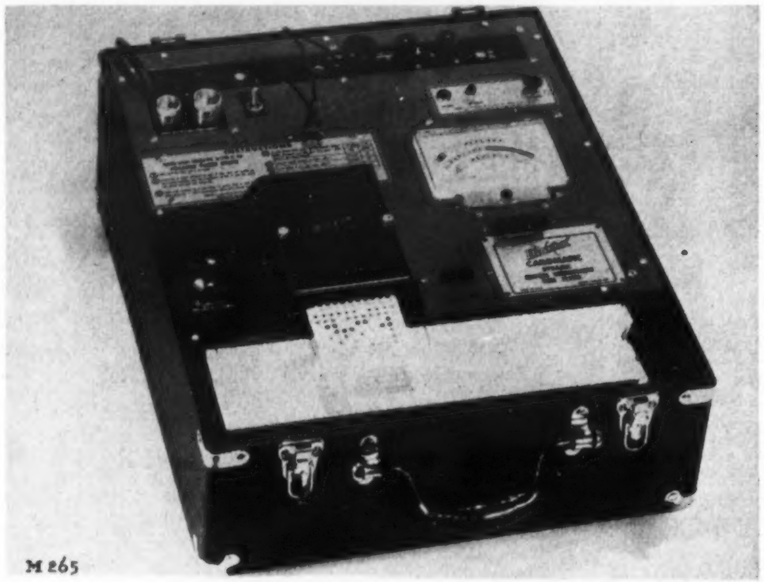
New Products—*Continued*



AUTOMATIZED TUBE TESTER

New "Model 123A Cardmatic Tube Testing Machine" utilizes a punched card system to automatically set and test to a user's specific circuit requirements. Preselected voltages on screen, plate, grid or filament are tabulated on vinyl type cards which are inserted into tester and trip a mechanism to make all electrical connections necessary for testing of any receiver tube. An infinitely large number of exactly-controlled voltages (formerly possible only in lab type testers) is available for testing tubes in special-purpose circuits. Unskilled personnel can run lab-accuracy tests on a production line basis.—*The Hickok Electrical Instrument Co.,* 10519 *Dupont Ave., Cleveland* 8, *Ohio.*

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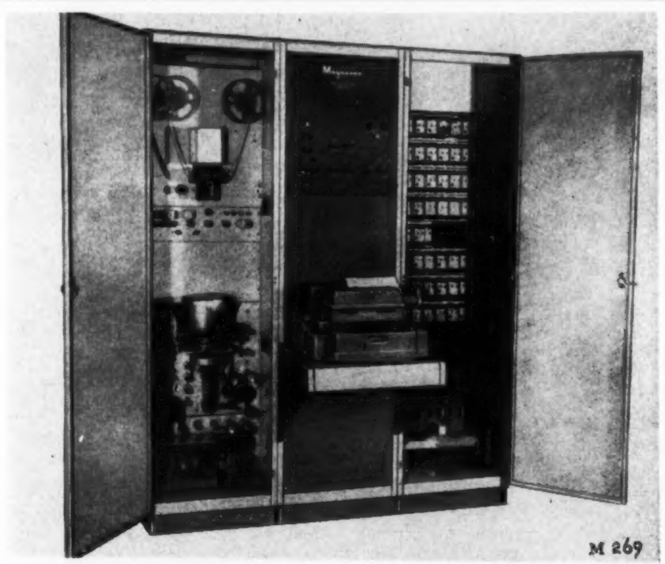


FILM DATA READING AND RECORDING SYSTEM

New system uses 16-mm and 35-mm cameras with speeds to 32 exposures per second to record digital information at rate of 2880 bits per second. Applications include control systems evaluation, theodolite recording, radar recording and document filing. System normally includes a camera with digital recording head, analog-to-digital converter, amplifiers, relays, control units, film reading system, decoding section, print-out equipment for visual examination of data and punched paper tape output recorders. —*Magnavox Co., Department NP, Fort Wayne* 4, *Ind.*

For more information circle **322** on inquiry card.

Lit Bits—*Continued*

Dampometer

The usual method to measure the damping of a mechanical or an electrical linear system is to let the system perform decaying oscillations and to register the amplitude of the oscillations as a function of time. The logarithmic decrement and the frequency can then be obtained, permitting the damping factor of the system to be determined. This procedure is straightforward but rather tedious. Furthermore, due to the many steps involved, the accuracy of the procedure is not always very good. There has, therefore, for a long time been a need for an apparatus designed to evaluate automatically the logarithmic decrement and the frequency of decaying oscillations. Such an apparatus, which gives the values of the above mentioned quantities in decimal digits simultaneously with the oscillation test, has now been constructed.

The "Dampometer"* is based on the idea of representing the harmonic damped oscillation by a rotating vector in such a way that the rate of decrease of the length of the vector is a measure of the damping of the oscillating system. The curve thus described by the end of the vector is a logarithmic spiral.

The oscillation to be investigated is introduced as a voltage to the four deflecting plates of the cathode-ray tube with a 90° phase shift between successive plates. The resulting reflection of the cathode ray, i.e. the length of the radius vector to the spot on the screen, is proportional to the ordinate of the envelopes of the oscillation. When the oscillation is damped, the spot moves on a logarithmic spiral towards the center of the screen (one revolution corresponding to one cycle of oscillation), as shown in Fig. 1.

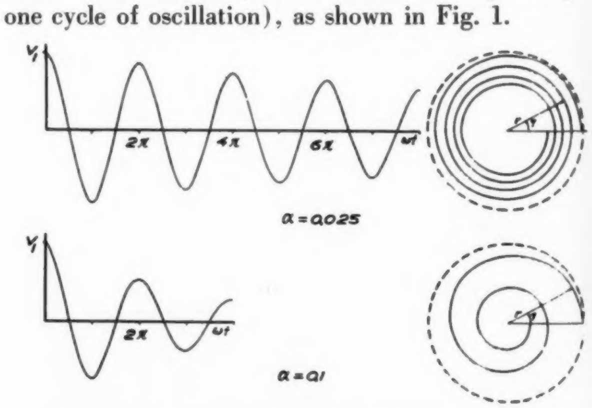


Fig. 1. Damped decay and its scope trace.

The screen is covered by a circular disk with a number of equally spaced radial slots, all of which are of the same length and are situated at the same distance from the center, see Fig. 2. While the spot moves on the spiral, it passes the slots in the screen and thus gives light pulses to a photocell. The number of pulses produced by the cathode ray, while the radius vector of the spiral decreases from the outer to the inner radius of the slots, is registered on an electronic counter, which gives the number directly in decimal digits.

* Patent applied for

The logarithmic decrement of the oscillation is inversely proportional to this number.

A second electronic counter is used to measure the time over a number of pulses thus determining the frequency of the oscillation.

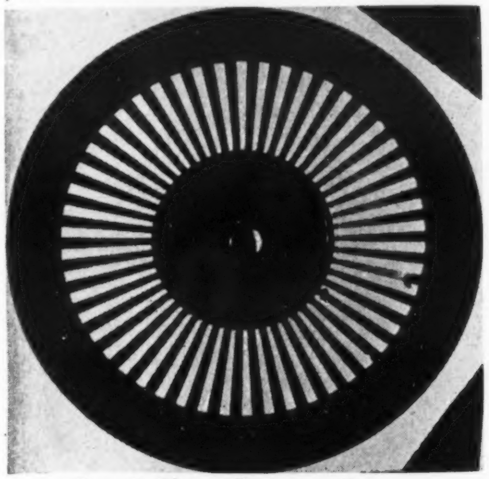


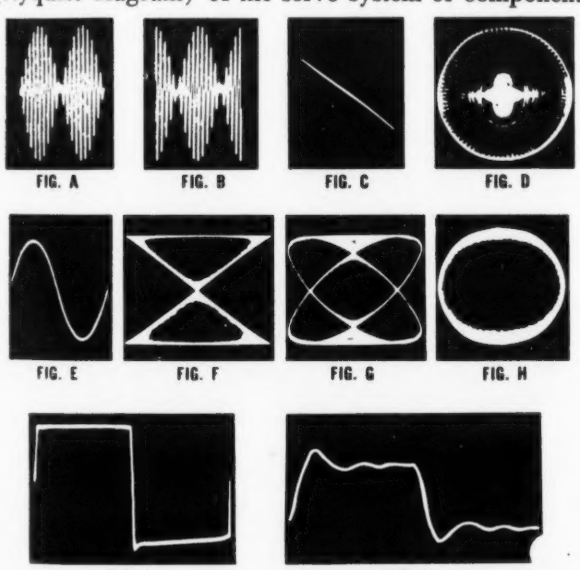
Fig. 2. Slots allow counting as beam spot traces its spiral.

The frequency range of the present apparatus is 0.5—500 cps, but the principle can be adapted to frequencies up to the order of 1 mc. (*From new 36-page brochure, Oltronix, 235 Underwood Dr., N. W., Atlanta 5, Ga.*)

For this literature circle **109** on inquiry card.

Servoscope Servo Analyzers

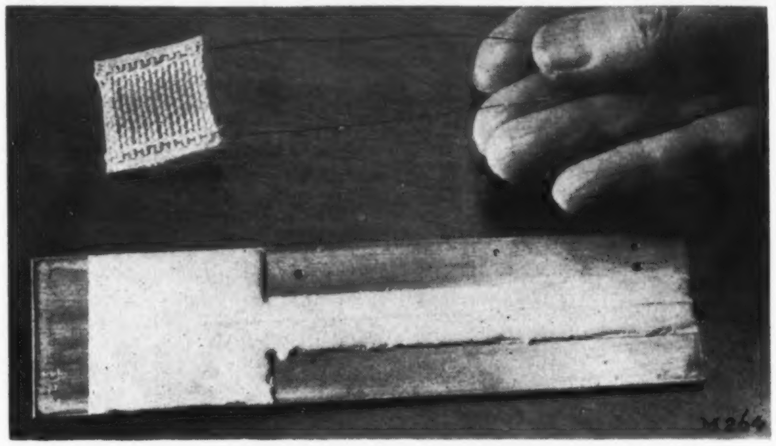
By measuring the relative amplitude of the output and input patterns and taking simultaneous phase readings, sufficient data is obtained to plot a phase and amplitude characteristic on the complex plane (Nyquist diagram) of the servo system or component.



Representative patterns

The data may also be used to plot a log amplitude—log frequency curve (Bode diagram) or a log amplitude—phase diagram (Nichols diagram). (*From new 4-page TDS 1100, Rev. 357, Servo Corp. of America, 20-20 Jericho Turnpike, New Hyde Park, N. Y.*)

For this literature circle **110** on inquiry card.



REFRACTORY CEMENT

New "CA-9" refractory cement will hold metal to metal, glass, or ceramics at temperatures from —420°F to 1000°F; is dielectric and highly shock-resistant throughout its temperature range (upper limit extendable to 1500°F modifying composition). Material remains slightly malleable after drying, hence will not crack, craze or check even if used on a repeatedly flexing surface or to join materials with widely different thermal expansion coefficients. It was developed to attach surface-temperature transducers, strain gages, and lead wires to the skins of guided missiles (see illus). A joint of "CA-9" between two pieces of metal will resist 80 psi shear force at ambient temperature up to 990°F. "CA-9" is waterproof, nonhygroscopic; unaffected by most reagents; is unaffected by 15 minutes of 45 *G* vibration through a 1" double amplitude at 1500 cps. Wires embedded in it are not shorted by complete submersion in water. "CA-9" is composed of ground phlogopite, a polysiloxane polymer, and refractory oxides.—*Charles Englehard, Inc., 850 Passaic Ave., East Newark, N. J.*

For more information circle **323** on inquiry card.

DOUBLE-ENDED COIL FORM

New "LS-14 double-ended miniature coil form allows space for primary and secondary windings, with separate tuning slugs for independent tuning of each section, is available in several frequency ranges. Approximate measurements ½" OD and 1¹³⁄₆₄" over-all length excluding tuning slugs. Available with up to six terminals; mounts by means of threaded middle section. Interior is made up of powdered iron components and main housing is nickel-plated brass. Tuning cores are held in adjustment by built-in locking devices. —*Cambridge Thermionic Corporation, 445 Concord Ave., Cambridge 38, Massachusetts.*

For more information circle **324** on inquiry card.

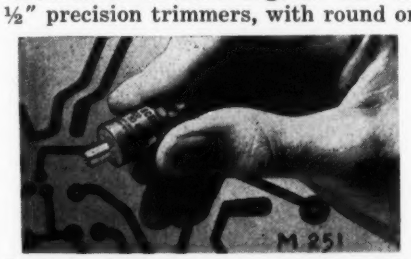
ACID-RESIST LACQUER

New "Nelco Stop-Off Lacquer" is said to possess "exceptional printing qualities that assure exact reproduction and complete retention of the deposited image." Formulated for silk screen printing of circuit design, it deposits a positive protective coating on metal or plastic laminate prior to acid bath operation. It air-dries tack-free in 30 min or can be force air-dried at 160°F for 5 to 10 min with the same results—whence elimination of baking operations. Its protection to lacquer-coated surfaces during etching, in regular production, cuts down incidence of broken circuits "by as much as 80% according to field reports."—*Chemical Products Corp., Dept. ARL, King Philip Road, East Providence, R. I.*

For more information circle **325** on inquiry card.

TRIMMERS

New "Acetrims," subminiature precision wire-wound units with tabs for printed circuit applications, have all features of maker's regular line of ½" precision trimmers, with round or

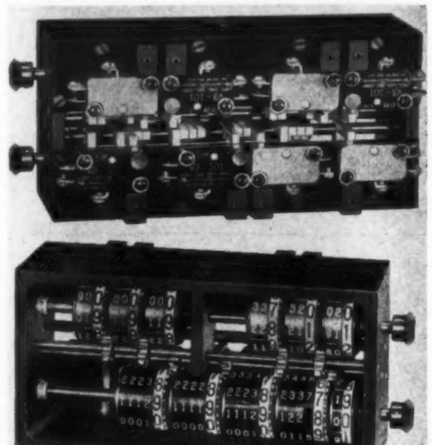


flat tabs in place of terminals; 10 to 150,000 ohms resistance; power 2 w @ 60°C max; temperature —55°C to 125°C; sealed; moisture-proofed; antifungus treated; withstands severe shock, vibration, acceleration; meets applicable MIL specs.—*Ace Electronics Associates, Inc., 103 Dover St., Somerville 44, Mass.*

For more information circle **326** on inquiry card.

PROGRAMMER COUNTER

New "Multiple Programmer Counter" for missile guidance systems, starting systems, etc., can be applied where a plurality of switch contacts would be required at selective predetermined numbers. It closes from one to eight or more switches at selective predetermined settings within a given range; can be set to give consecutive contacts at such varied numbers as



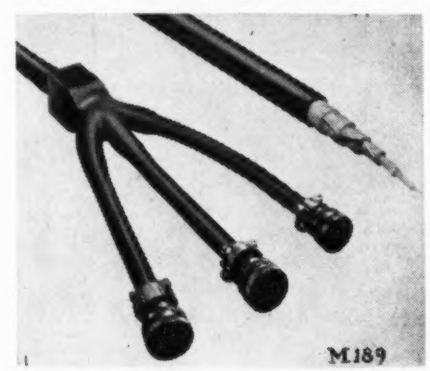
M 262

4, 158, 975, 40128. Mechanically, it is a double-deck end-drive predetermined counter for rotary drive. Case size 5-⅞" L, 3" H, 2-½" D; speed 500 rpm at input shaft; weight 35.5 oz. Meets MIL spec covering salt spray, humidity, temperature, and fungus.—*Durant Mfg. Co.*, 1914 *N. Buffum St., Milwaukee* 1, *Wis.*

For more information circle **327** on inquiry card.

"BREAKOUT"

New multi-branch multi-conductor "breakout" cable, developed specifically for missle wiring, but adaptable



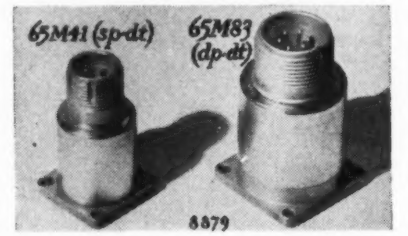
M189

to commercial applications. There are 141 conductors, layed by a specially constructed planetary strander. Although terminating in a 3-branch "breakout" this cable permits continuous circuitry as there is no junction in "breakout." Moreover circuits can be completed between any two or all three branches without originating in the prime cable.—*Pacific Automation Products, Inc.*, 1000 *Air Way, Glendale* 1, *Calif.*

For more information circle **328** on inquiry card.

POSITION SWITCH

New "Capswitch," developed for use in aircraft and guided missiles but adaptable to any type of control

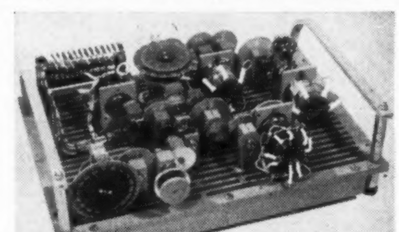


where repeatability within 0.001" is desired, signals when a valve (or other device) has completed its closing or opening cycle. It is mechanically actuated by a sealed plunger, which is depressed by valve stem or other member.—*Bridgeport Thermostat Div., Robertshaw-Fulton Controls Co., Milford, Conn.*

For more information circle **329** on inquiry card.

SERVOMECHANICAL PARTS

New parts designed especially for airborne 400-cps servo systems in applications where space is at a premium and low system inertias are required, comprise all essential mechanical parts: not only dial assemblies,



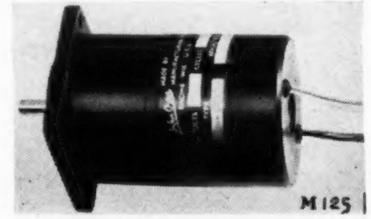
8772

couplings, differentials, etc., but a complete line of precision class II gears; can be purchased separately or in kit form.—*Reeves Instrument Corp.*, 207 *E.* 91*st St., New York* 28, *N. Y.*

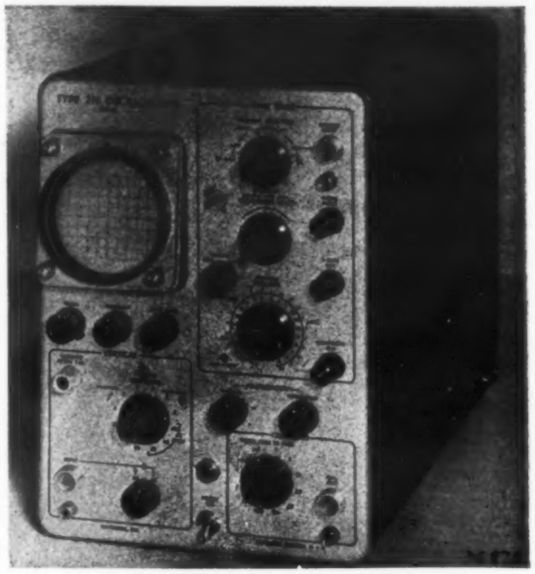
For more information circle **330** on inquiry card.

GEARMOTOR

New "Type 5602-02" size-18 low-speed high-torque motor-gear-train with unusually great output for its



M125



CATHODE-RAY OSCILLOSCOPE

New "Type 316" combines a dc-to-10-Mc pass-band, high sensitivity, and wide sweep range in a 35-lb instrument 12" high and 19½" deep. Vertical amplifier has 12 calibrated deflection steps from 0.01 v/div to 50 v/div with ac-coupled steps from 0.01 v/div to 0.05 v/div; 0.035-usec rise-time from 0.1 to 125 v/div, 0.04-usec rise-time from 0.01 v/div to 0.1 v/div; balanced 0.25-usec delay network. Time base has 22 calibrated steps from 0.2 usec/div to 2 sec/div, 5× magnifier and triggering circuitry with preset stability for all triggering modes. Other features are 1.85-kv accelerating potential on a new Tektronix 3" cathode-ray tube with 8×10-div linear viewing area, electronically-regulated power supplies, and square-wave voltage calibrator.—*Tektronix, Inc., P.O. Box 831, Portland 7, Oregon.*

For more information circle **332** on inquiry card.

size can be operated in temperatures as low as −55°C. Length 2.8"; output torque 25 oz-in at 1.7 rpm unloaded. Rated for continuous duty at 115v 60 cps. Available with flange or other mounting types and with brake if desired.—*John Oster Mfg. Co., Avonic Div., Racine, Wis.*

For more information circle **331** on inquiry card.

TEFLON-AIR COAXIAL CABLE

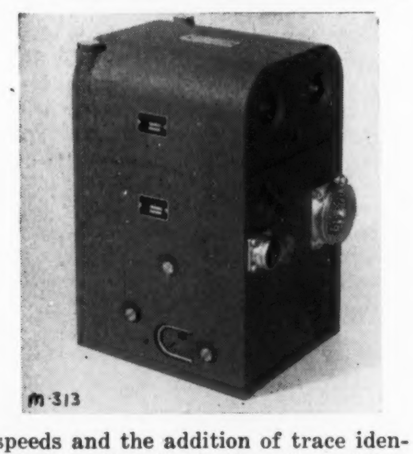
New High-Temperature Low-Capacitance Teflon Air Dielectric miniature 0.220"; conductor is #30 AWG, 738 silver-plated copperweld. Choice of

outer jackets of Teflon, lacquered nylon braid, Teflon or silicone-impregnated glass braid, etc. Low attenuation makes cable particularly useful for HF low-level applications and as low-capacitance probe cable. Capacitance values of less than 10 mmf available on request.—*Tensolite Insulated Wire Co., Inc., 198 Main St., Tarrytown, N. Y.*

For more information circle **333** on inquiry card.

RECORDING OSCILLOGRAPH

New Model 561 oscillograph features ruggedness, small size (5" x 6" x 9") and wide range of recording

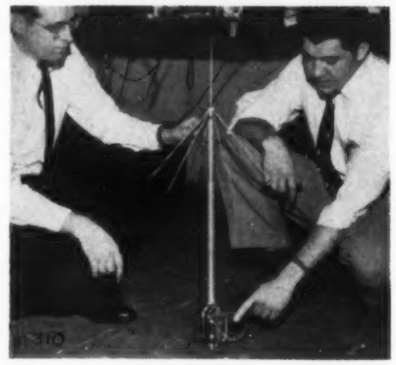


speeds and the addition of trace identification. Speed selections from 0.5 to 80 inches per second, with a magazine capacity of 92 feet of recording paper and beam-type interrupter identification.—*Midwestern Instruments, Tulsa, Okla.*

For more information circle **334** on inquiry card.

BEACON TRANSMITTER

New completely transistorized UHF Beacon Transmitter is so small that it has been built inside a standard



size sardine can. Using printed circuitry throughout it is capable of sending radio signals a distance of 25 miles continuously for a period of 24 hours. Designed primarily for military applications as an emergency signalling and communications device, the "sardine can" transmitter can be modified for voice or code operation at frequencies other than the 280 to 322 mc for which it was designed.—*Electronics Div., Fairchild Controls Corp., Robbins Lane, Syosset, L. I., N. Y.*

For more information circle **335** on inquiry card.

MICROWAVE COAXIAL ATTENUATOR

New Coaxial Continuously Variable Broadband Attenuator is said to be the first broadband, very low inser-

tion loss attenuator in the field. The insertion loss is 1 db maximum for 40 db unit and ½ db maximum for 20 db unit. The operating range is any 100% band width from the frequencies 100 to 3300 mc. Accuracy is +0.25 db for 100% frequency range. Essentially linear scale is 7" long. *Douglas Microwave Co., Inc., 252 E. Third St., Mt. Vernon, N. Y.*

For more information circle **336** on inquiry card.

VARIABLE DELAY UNITS

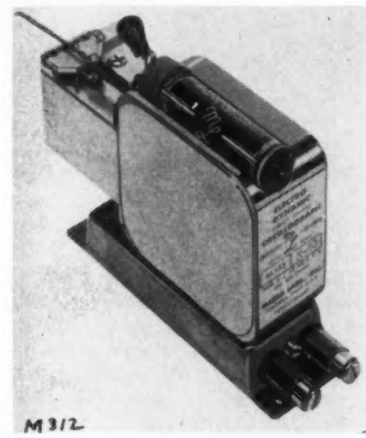
New continuously variable delay lines Models 501 to 505 feature delay ranges of 0—0.9 microseconds to 0—15.0 microseconds. A single control shaft, in ten turns, covers the en-

tire delay range from zero to maximum. Resolution is better than 1/1000 of maximum delay. Termination is external. Outside dimensions are 7¼" x1"x1⅝". The new units meet all applicable Mil-Specs.—*ESC Corp., 534 Bergen Blvd., Palisades Park, N. J.*

For more information circle **337** on inquiry card.

MULTI-CHANNEL OSCILLOGRAPH

New Model M-133 pen motor is a compact, lightweight unit especially designed for multi-channel recording

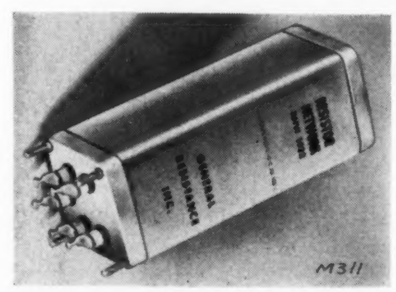


systems. Over-all dimensions are 4¾" long x 1¼" wide x 3⅞" high. Weight—1½ lbs. A built-in micrometer set screw makes possible accurate pen alignment to a common time axis. The M-133 pen motor is direct linking. Features include true rectilinear motion of the pen tip due to a novel linkage assembly, excellent transient response due to critical acoustic damping, current input flat from dc to 60 cps.—*Massa Laboratories, Inc., 5 Fottler Road, Hingham, Mass.*

For more information circle **338** on inquiry card.

PRECISION RESISTANCE NETWORK

New precision resistance network splits 600 volts into two parts within 0.01% over the temperature range of

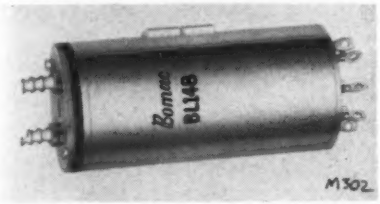


0°C to 100°C and under adverse environmental conditions. Network is completely encapsulated and hermetically sealed.—*General Resistance, Inc., Dept. 19, 577 E. 156 St., New York 55, N. Y.*

For more information circle **339** on inquiry card.

NETWORK SWITCHING TUBE

New BL-148 is a high voltage, hermetically sealed, armature type relay developed for switching radar pulse



forming networks. One set of SPST high-voltage switch elements and two sets of low-voltage SPST elements are simultaneously operated from a 26.5-v d-c source. It can handle high voltages without breakdown.—*Bomac Laboratories, Inc., Salem Road, Beverly, Mass.*

For more information circle **340** on inquiry card.

VERTICAL GYRO

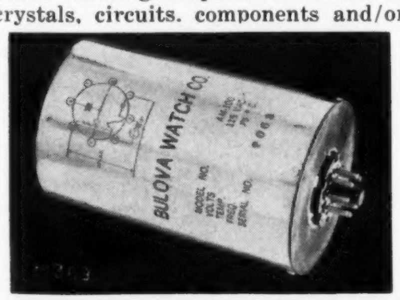
New vertical gyro type WG-2 provides two-axis vertical reference data. The spin-axis is slaved to gravity by

a gravity-sensitive vertical reference which supplies control signals to torque motors which maintain the gyro spin-axis parallel to the gravity vector. Output signals are supplied by two synchros coupled to the gimbal axes and are proportional to sines of the angle of displacement of the gyro base axis from the vertical. —*Waltham Watch Co., c/o. Harry Brager Associates,* 1457 *Broadway, New York* 36, *N. Y.*

For more information circle **341** on inquiry card.

OVEN

New "multi-purpose" AM-100 oven yields exacting temperature control of crystals, circuits, components and/or

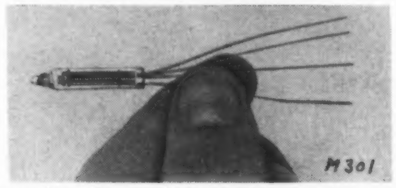


complete sub-assemblies. Features include stability of ±0.1°C. Standard octal plug-in (stud mounting available).—*Bulova Watch Co., Electronic Div., P-765, Woodside* 77, *N. Y.*

For more information circle **342** on inquiry card.

COMPUTER INDICATOR TUBE

New Type 6977 filamentary subminiature indicator triode with fluorescent anode is designed for visual

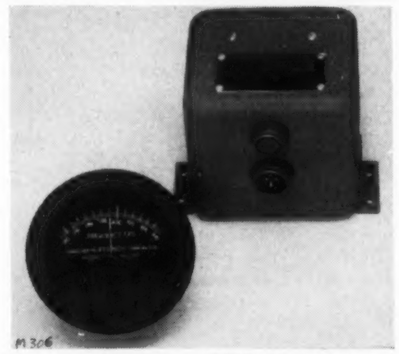


monitoring of transistorized computers and other transistor circuits. The 6977 is approximately 1⅛" long and less than ¼" in diameter. It gives a bright blue-green indication when its control grid is at zero potential. It is designed for 20,000 hours life. The heater voltage is only 1 volt, 30 ma, ac or dc.—*Computer Products Div., Amperex Electronic Corp.,* 230 *Duffy Avenue, Hicksville, L. I., N. Y.*

For more information circle **343** on inquiry card.

FREQUENCY METER

New 400-cps Model 200 frequency meter for aircraft instrument panels is designed in conformance with mili-

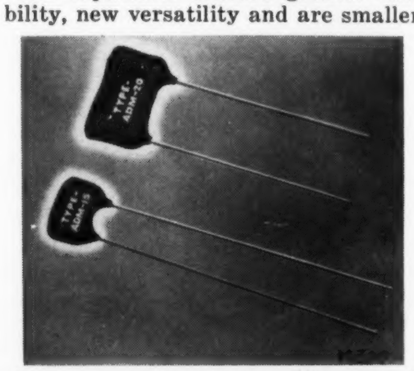


tary specification (MIL-E-5400) and provides ¼ of 1% accuracy over the temperature range −55°C to 70°C.—*Consolidated Avionics Corp., Stamford, Conn.*

For more information circle **344** on inquiry card.

MICA CAPACITORS

New line of plastic-coated dipped-mica capacitors feature greater stability, new versatility and are smaller



than conventional units. Meeting all the applicable RETMA test standards for molded mica capacitors these units offer long life and improved temperature coefficient range.—*Application Engineering Dept., Aerovox Corp., New Bedford, Mass.*

For more information circle **345** on inquiry card.

ELECTRONIC COMPONENTS

COMPONENTS for automatic control of aerodynamic research and testing facilities are described in new 20-page Bulletin MSP-133.—Hagan Corporation, Hagan Bldg., Pittsburgh 30, Pa.
Circle **401** on inquiry card.

MICROWAVE COMPONENTS are described in new 8-page Bulletin 317.—Varian Associates, Palo Alto, Calif.
Circle **402** on inquiry card.

RF PROBE tunable over 900 to 18,000 mc is described in new 2-page data sheet.—The Narda Corp., 160 Herricks Rd., Mineola, L. I., N. Y.
Circle **403** on inquiry card.

MICROWAVE ABSORBERS that simulate free space are described in new 4-page reprint.—Emerson & Cuming, Inc., 869 Washington St., Canton, Mass.
Circle **404** on inquiry card.

DIFFERENTIAL TRANSFORMER uses are described and associated circuitry shown schematically in 8-page bulletin reprint.—Automatic Temperature Control Co., Inc., 5200 Pulaski Ave., Phila. 44, Pa.
Circle **405** on inquiry card.

POTENTIOMETER specs for general and sine-cosine type pots are given in 2-page reprint.—Accuracy Inc., 4 Gordon St., Waltham, Mass.
Circle **406** on inquiry card.

ACCELEROMETER incorporating a variable linear transformer is described in new 4-page Data Sheet 20.—Genisco Inc., 2233 Federal Ave., Los Angeles 64, Calif.
Circle **407** on inquiry card.

THERMOCOUPLES for aircraft gas turbines and related aviation applications are described in new 4-page Bulletin MC-153.—Aviation Products Div., Fenwal Inc., Ashland, Mass.
Circle **408** on inquiry card.

DIGITAL and alpha-numerical indicator specifications and illustrations are given in new 4-page Bulletin 1011.—Union Switch and Signal, Div. of Westinghouse Air Brake Co., Pittsburgh 18, Pa.
Circle **409** on inquiry card.

EXPLOSIVE ACTUATED VALVES, including normally open and normally closed types that can store liquid or gas at pressures up to 5000 psi are described in new 8-page brochure.—Conax Corp., 2300 Walden Ave., Buffalo 25, N. Y.
Circle **410** on inquiry card.

TAPE WOUND CORES Catalog TWC-200 is design manual including 28 pages of data on magnetic terminology, design equations, material characteristics and testing data.—Magnetics, Inc., Butler, Pa.
Circle **411** on inquiry card.

MINIATURE MAGNETIC CLUTCHES are featured in "Helinews" No. 16 which also includes variable delay lines, pots, etc.—Helipot Corp., Division of Beckman Instruments, Inc., Newport Beach, Calif.
Circle **412** on inquiry card.

MICRO-MINIATURE CAPACITORS for low-voltage d-c applications (such as 0.095" x 0.195", 8 uf, 1-v unit) are described in a new 4-page Bulletin GEA-6065C.—General Electric Co., Schenectady, N. Y.
Circle **413** on inquiry card.

ELECTRONIC TRANSFORMER characteristics, prices and dimensions are presented in new 32-page Catalog TR-57.—Triad Transformer Corp., 4055 Redwood Ave., Venice, Calif.
Circle **414** no inquiry card.

BALL/DISC INTEGRATOR operation and applications are described in new 6-page Catalog 304061.—Librascope, Inc., 808 Western Ave., Glendale 1, Calif.
Circle **415** on inquiry card.

DC SOLENOIDS, miniature and subminiature, are described in two new 2-page reference sheets.—PSP Engineering Co., 6058 Walker Ave., Maywood, Calif.
Circle **416** on inquiry card.

MAGNETIC AMPLIFIER characteristics, specs, and circuit connections are presented in new 16-page product catalog.—Litton Industries, Maryland Div., 4910 Calvert Rd., College Park, Md.
Circle **417** on inquiry card.

MAGNETIC AMPLIFIERS for 60- and 400-cps operation are described in new 6-page Bulletin S235B.—Magnetic Amplifiers,Inc., 632 Tinton Ave., New York 55, N. Y.
Circle **418** on inquiry card.

MAGNETIC AMPLIFIER is presented for use in servo system with the Kearfott R110-2, 400-cps servo motor in 2-page Bulletin C-129-5100.—The Ahrendt Instrument Co., 4910 Calvert Rd., College Park, Md.
Circle **419** on inquiry card.

WAVEGUIDE COMPONENTS. New 4-page catalog lists maker's line of microwave components and test equipment.—Microwave Associates Inc., Burlington, Mass.
Circle **420** on inquiry card.

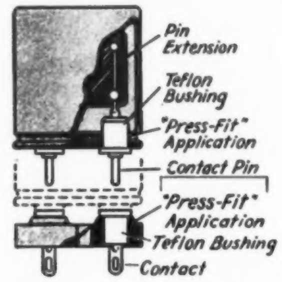
RESISTORS. New 12-page Bulletin C-lb contains data on maker's tubular and flat Power Wire Wound Resistors.—International Resistance Co., 401 N. Broad St., Phila. 8, Pa.
Circle **421** on inquiry card.

CARBON FILM RESISTORS. New 2-page Catalog 307-1056 describes maker's new low-cost carbon film resistors and provides mechanical and electrical characteristics.—Continental Carbon, Div. of Wirt Co., 5221 Greene St., Phila. 44, Pa.
Circle **422** on inquiry card.

DELAY LINES. New 4-page Bulletin 17 provides information on applications, specifications, electrical and mechanical characteristics, of maker's high-impedance delay lines with magnetic core.—Columbia Technical Corp., 61-02 31st Ave., Woodside 77, N. J.
Circle **423** on inquiry card.

Lit Bits—*Continued*

"Press-Fit" Teflon Terminals

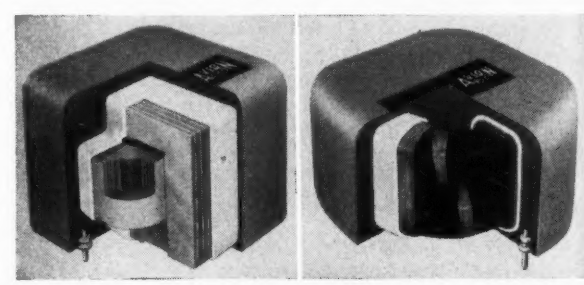


These stand-off and feedthru terminals are available in both miniature and subminiature sizes. "Press-Fit" means: Easiest to install, superior in electrical, thermal, chemical and mechanical properties; eliminating hardware; minimizing assembly labor; and costing less than glass, ceramic or other types. For ultra-high-frequency operations, "Press-Fit" terminals are designed to operate at frequencies far above the 200 megacycle limit for glass or ceramic insulators. Overall length and O. D. sizes of "Press-Fit" terminals are greatly reduced over stand-offs and feed-thrus of other insulation material. Exceptionally high insulation favors miniaturization and sub-miniaturization programs. Typical "Press-Fit" connector application is illustrated. Engineering data on 75 standard parts are listed. (*From new 8-page Bulletin, "Press-Fit" Teflon Terminals, Sealectro Corporation,* 610 *Fayette Ave., Mamaroneck, N. Y.*)

For this literature circle **111** on inquiry card.

Special Magnetics

The Avion Division of ACF Industries, Inc., brings to the electronic industry a complete service to meet your requirements in transformers, chokes, inductors, saturable reactors, magnetic amplifiers, servo amplifiers, special power supplies, frequency multipliers and other encapsulated magnetic circuits. This program was initiated to meet Avion's own requirements for special magnetics with performance characteristics exceeding those of the ordinary stock variety; and further, to facilitate prompt availability for proto-types as well as production quantities required for both military and industrial application. Individual components can be the development of an original design; the production of your own design; or the reproduction of existing magnetics. Small quantities for models and prototypes or production quantities, direct from plant to customer. (*From new 2-page bulletin, Avion Div., ACF Industries, Inc.,* 11 *Park Place, Paramus, N. J.*)



For this literature circle **112** on inquiry card.

EVENTS

August 5-10

National Naval Aviation Meeting, sponsored by Institute of Aeronautical Sciences and its San Diego Section, U. S. Grant Hotel, San Diego, Calif.

August 20-23

Western Electronic Show and Convention, Cow Palace, San Francisco, Calif. (See page 129)

August 26-30

Eighth Annual Infrared Spectroscopy Institute, Fisk University, Nashville 8. Tenn. For information write Nelson Fulson, Infrared Spectroscopy Institute, Fisk University, Nashville, Tenn.

September 4-6

Second Technical Conference and Exhibit on Magnetic Amplifiers, Penn Sheraton, Pittsburgh, Pa. For information write David Feldman, Bell Telephone Labs., Whippany, N. J.

October 3-4

Tenth Annual Quartermaster Association Convention, San Francisco, Calif. For more information write, Col. A. L. Bivens, president, Northern California Chapter, Q.A., P. O. Box 105, Presidio of San Francisco, Calif.

October 24-25

Fourteenth Annual Display of Aviation Electrical Equipment, Pan Pacific Auditorium, Los Angeles. For information write Mr. Howard Ryerson, care of Lynn-Western, Inc., 6901 Melrose Ave., Los Angeles 38, Calif.

November 5-6

Joint Military Industry Guided Missile Reliability Symposium, Naval Air Missile Test Center, Pt. Mugu, Calif. Persons desiring to attend must have a Secret security clearance and should make known their plans by August 15 to Commander, USNAMTC, Reliability Symposium, Code CEN-1, U. S. Naval Air Missile Test Center, Point Mugu, Calif.

December 6-7

American Rocket Society, Eastern Regional Student Conference, Hotel Statler, New York, N. Y. For information write Mr. Mario W. Cardullo, Pres., Polytechnic Chapter, ARS, Polytechnic Institute of Brooklyn, 99 Livingston St., Brooklyn 1, N. Y.

June 9-13, 1958

Fourth International Automation Congress & Exposition and First Military Automation Exposition, Coliseum, New York, N. Y. For information write to Richard Rimbach Associates, 845 Ridge Ave., Pittsburgh 12, Pa.

TUBES, TRANSISTORS

MICROWAVE TUBES. Klystrons, BWD's, TWT's, etc. are described in new 31-page Catalog 311.—Varian Associates, 611 Hansey Way, Palo Alto, Calif.
Circle **424** on inquiry card.

MEDIUM-MU TWIN TRIODE, a 9-pin miniature type tube designed for use in electronic computers, particularly high-speed digital type, and in other "on-off" control equipment is described in a new 4-page Bulletin 6350. —Radio Corp. of America, Tube Div., Harrison, N. J.
Circle **425** on inquiry card.

TRANSISTORS, DIODES and rectifiers are described in new 4-page Bulletin TE- 1340.—Transitron Electronic Corp., Wakefield, Mass.
Circle **426** on inquiry card.

ELECTRONIC TUBES. New Technical Handbook covers complete line of Swedish-made Ericsson electronic tubes. Included are complete ratings and characteristic curves.—State Labs Inc., 649 Broadway, New York 12, N. Y.
Circle **427** on inquiry card.

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MOTORS, SYNCHROS

MOTOR performance curves and engineering data for a-c motors and 1- and 1½-inch blowers are presented in 2-page bulletin.—Induction Motors Corp., 570 Main St., Westbury, L.I., N. Y.
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SYNCHROS with 3-minute accuracy are specified in new 4-page Bulletin 409.—Norden-Ketay Corp., Western Div., 13210 Crenshaw Blvd., Gardena, Calif.
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DYNAMOTORS with output to 100 w are described in new 2-page data sheet providing engineering design and performance data on maker's new line of dynamotors.—Induction Motors Corp., 570 Main St., Westbury, L.I., N. Y.
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SPECIALTY MOTOR fan and blower characteristics are presented in new 14-page Catalog 83.—Ashland Electric Products, Inc., 32-02 Queens Blvd., Long Island City 1, N. Y.
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PRECISION FINE PITCH GEARS are described and gear data formats presented in new 12-page brochure.—Precision Gear Department, Fairchild Camera and Instrument Corp., Robbins Lane, Syosset, L. I., N. Y.
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SWITCHES, RELAYS

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RELAYS, r-f systems and components, timers, etc. are described in new 16-page catalog.—Electronic Specialty Co., 5121 San Fernando Rd., Los Angeles 39, Calif.
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ELECTRONIC INSTRUMENTS

VOLTAGE REGULATORS are featured in new 14-page Bulletin TE 1352 "Silicon Voltage Regulators and References."—Transitron Electronic Corp., Wakefield, Mass.
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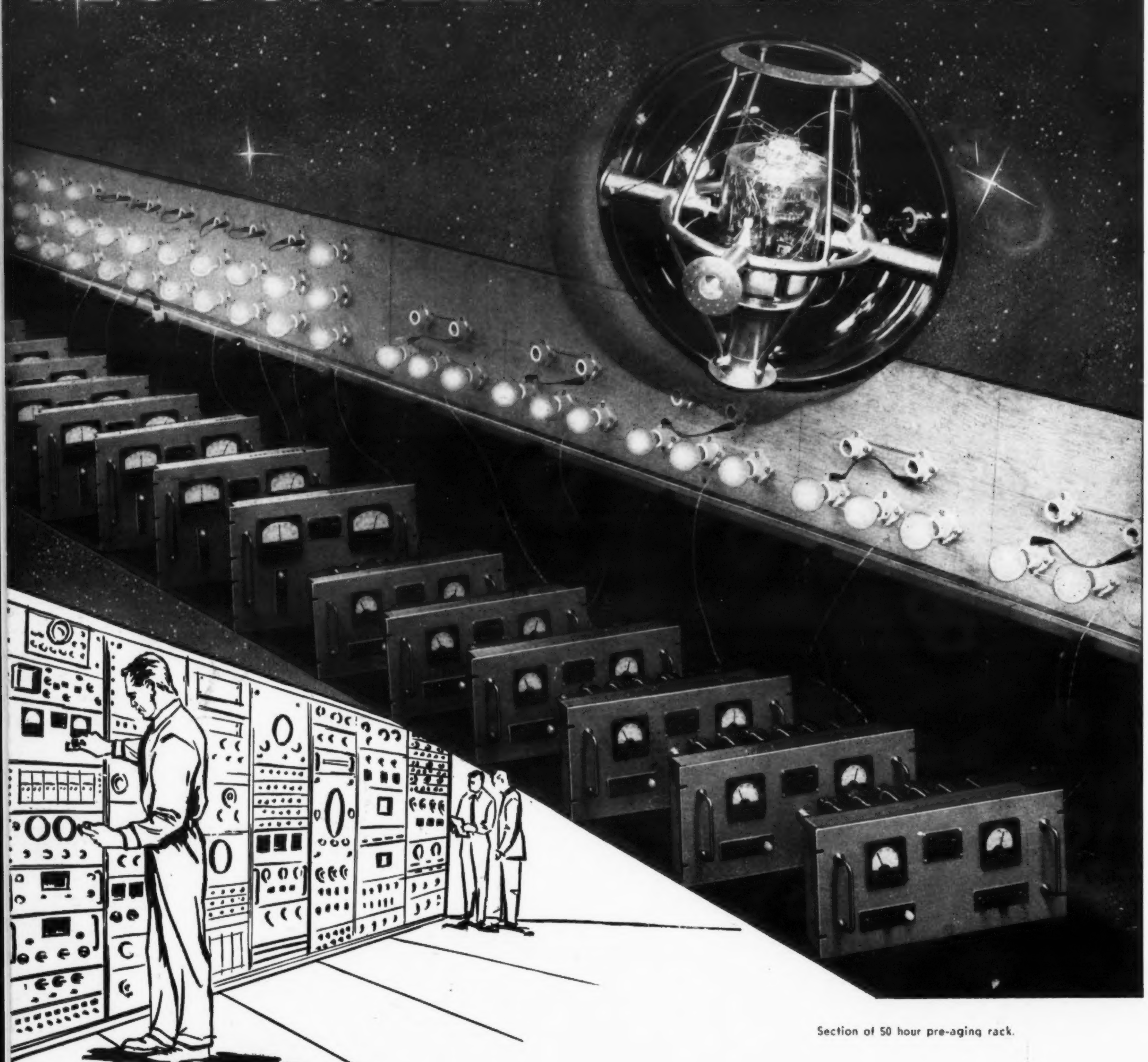

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